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Bath et al.

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(54) **HUMIDIFIER RESERVOIR**

(56) **References Cited**

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(73) Assignee: **ResMed Limited**, Bella Vista (AU)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 157 days.

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APEX XT-Auto Instruction Manual, USPTO to assume before Applicant's filing date.

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(65) **Prior Publication Data**

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Primary Examiner — T. Bennett McKenzie

(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(30) **Foreign Application Priority Data**

Mar. 15, 2013 (AU) 2013900901

(57) **ABSTRACT**

(51) **Int. Cl.**
A61M 16/00 (2006.01)
A61M 16/16 (2006.01)

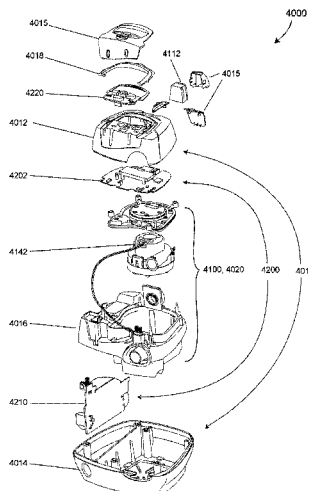
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(52) **U.S. Cl.**
CPC **A61M 16/16** (2013.01); **A61M 16/0051** (2013.01); **A61M 16/0683** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61M 2205/3368; A61M 2205/42; A61M 2205/123; A61M 2016/0039;
(Continued)

An apparatus for humidifying a flow of pressurized, breathable air includes varying a first pressure of the flow of breathable gas to vary a level of thermal engagement between the conductive portion of the reservoir and the heater plate, varying a height of the variable portion varies a level of thermal engagement between the conductive portion of the reservoir and the heater plate, use of a humidifier reservoir base component with a maximum water capacity substantially equal to the predetermined maximum volume of water of the humidifier reservoir or the use of intersecting inlet and outlet axes.

28 Claims, 35 Drawing Sheets



- (51) **Int. Cl.**
A61M 16/06 (2006.01)
A61M 16/10 (2006.01)
- (52) **U.S. Cl.**
 CPC **A61M 16/109** (2014.02); **A61M 16/0066**
 (2013.01); **A61M 16/161** (2014.02); **A61M**
2016/0039 (2013.01); **A61M 2205/123**
 (2013.01); **A61M 2205/3368** (2013.01); **A61M**
2205/42 (2013.01)
- (58) **Field of Classification Search**
 CPC A61M 16/1045; A61M 16/16–16/161; A61M
 16/0683; A61M 16/0066
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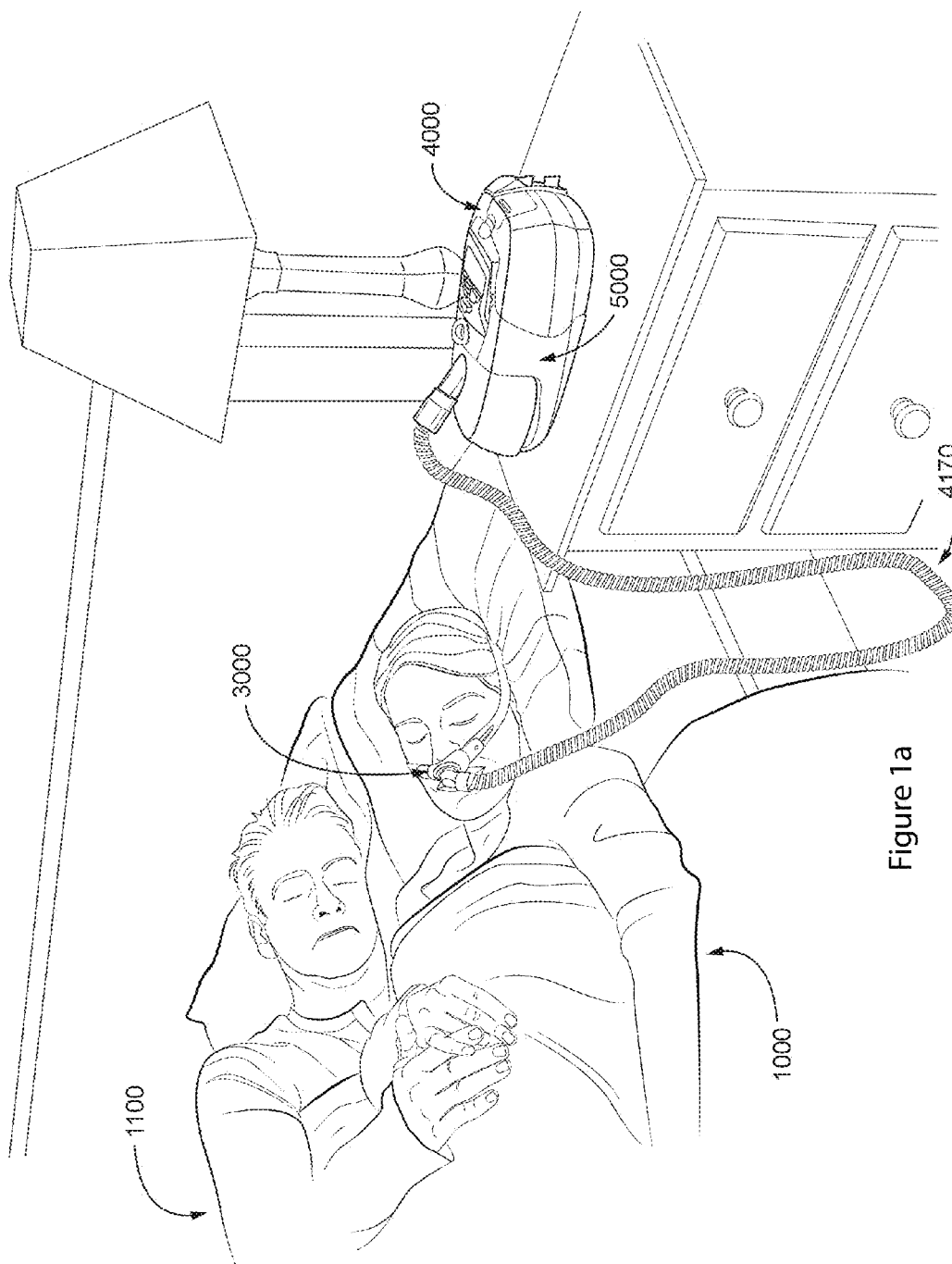


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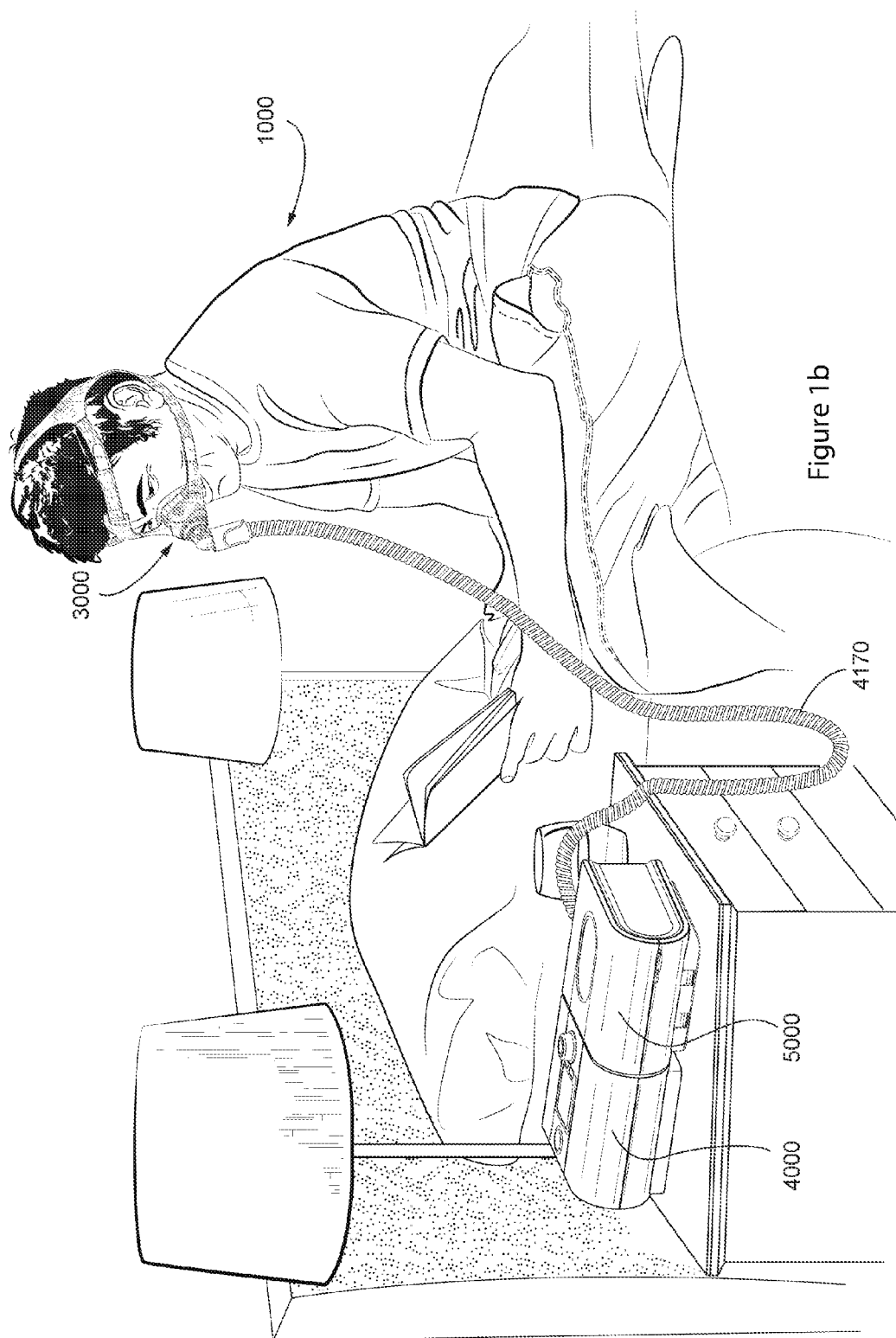


Figure 1b



Figure 1c

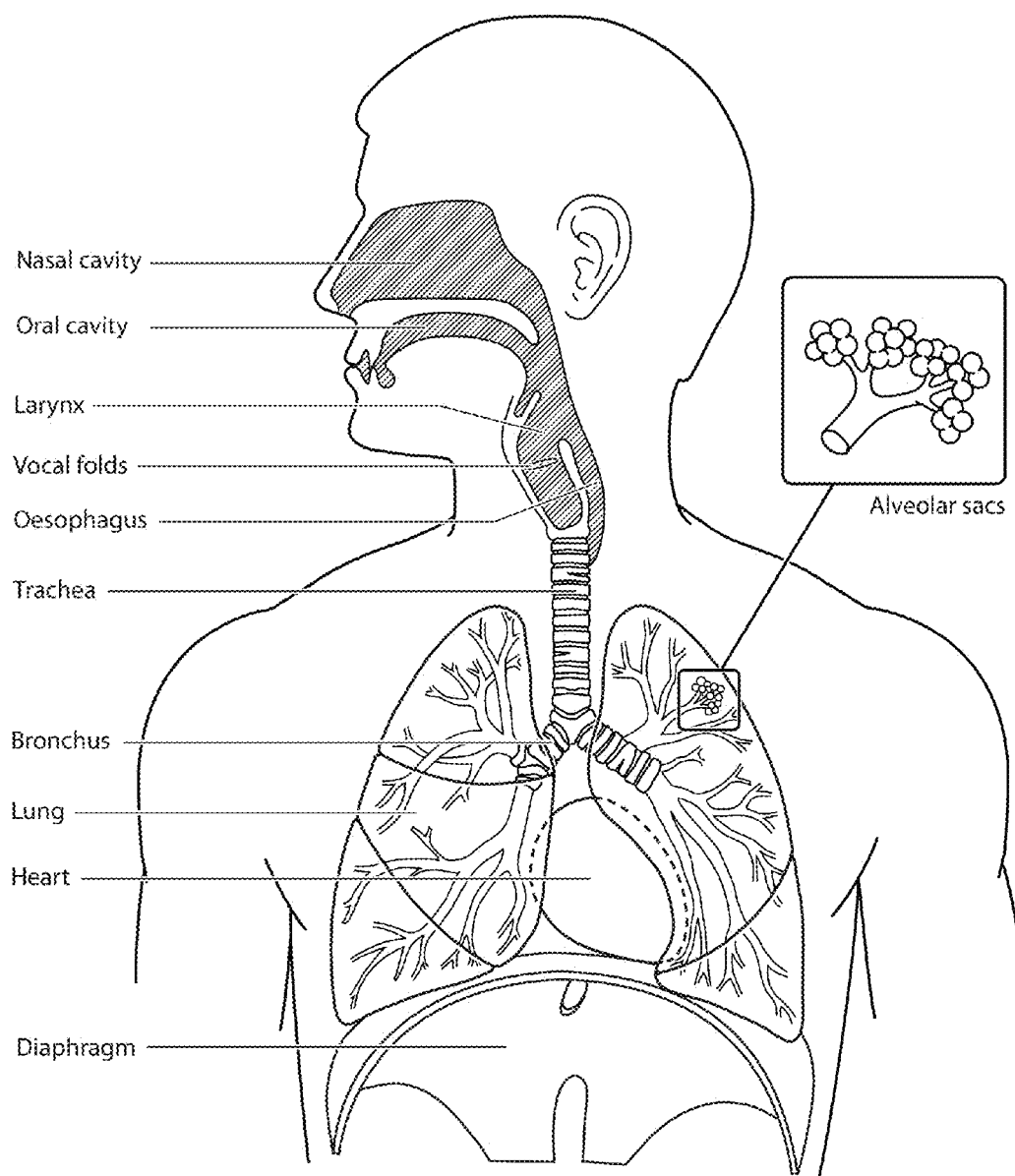


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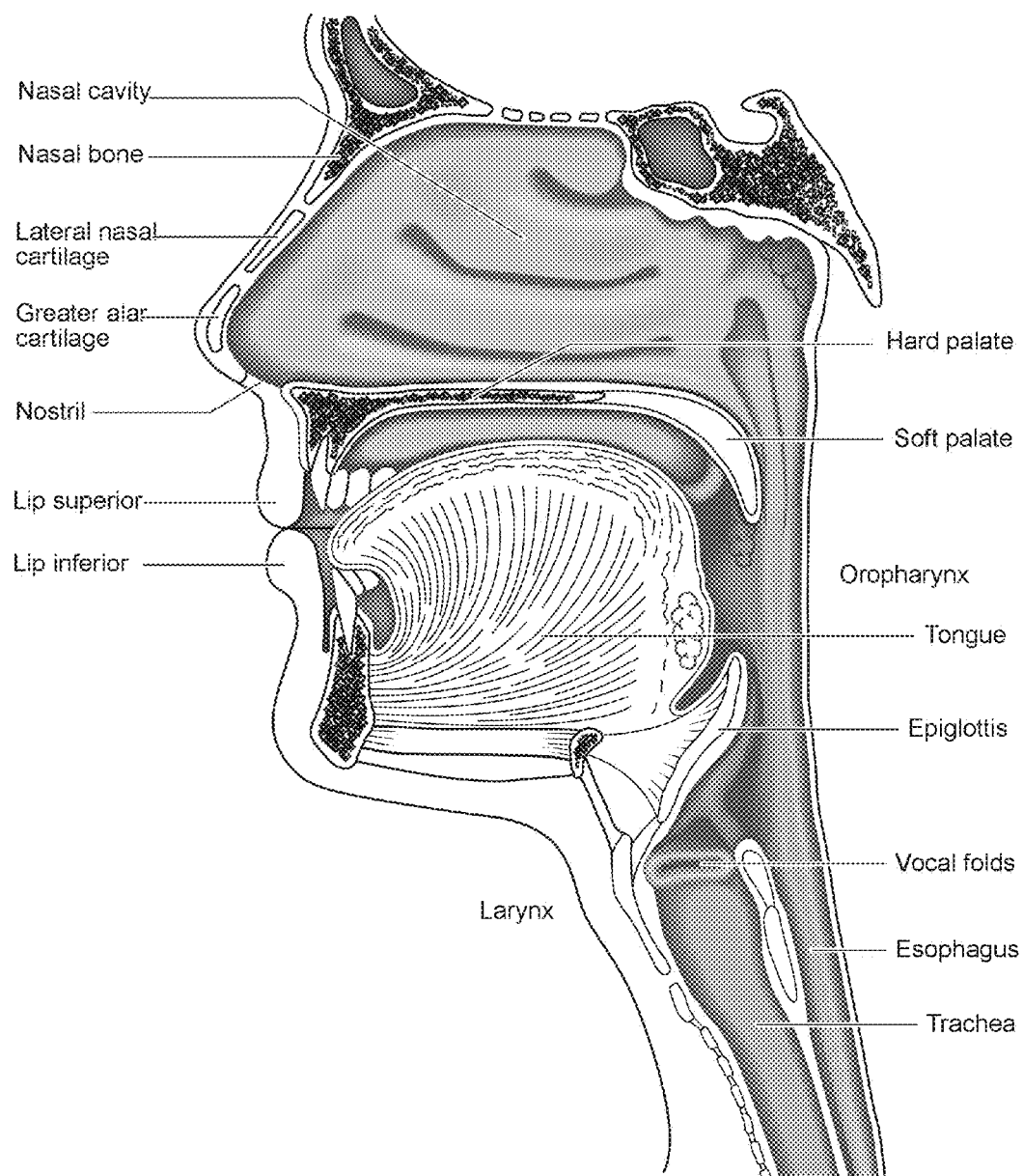


Figure 2b

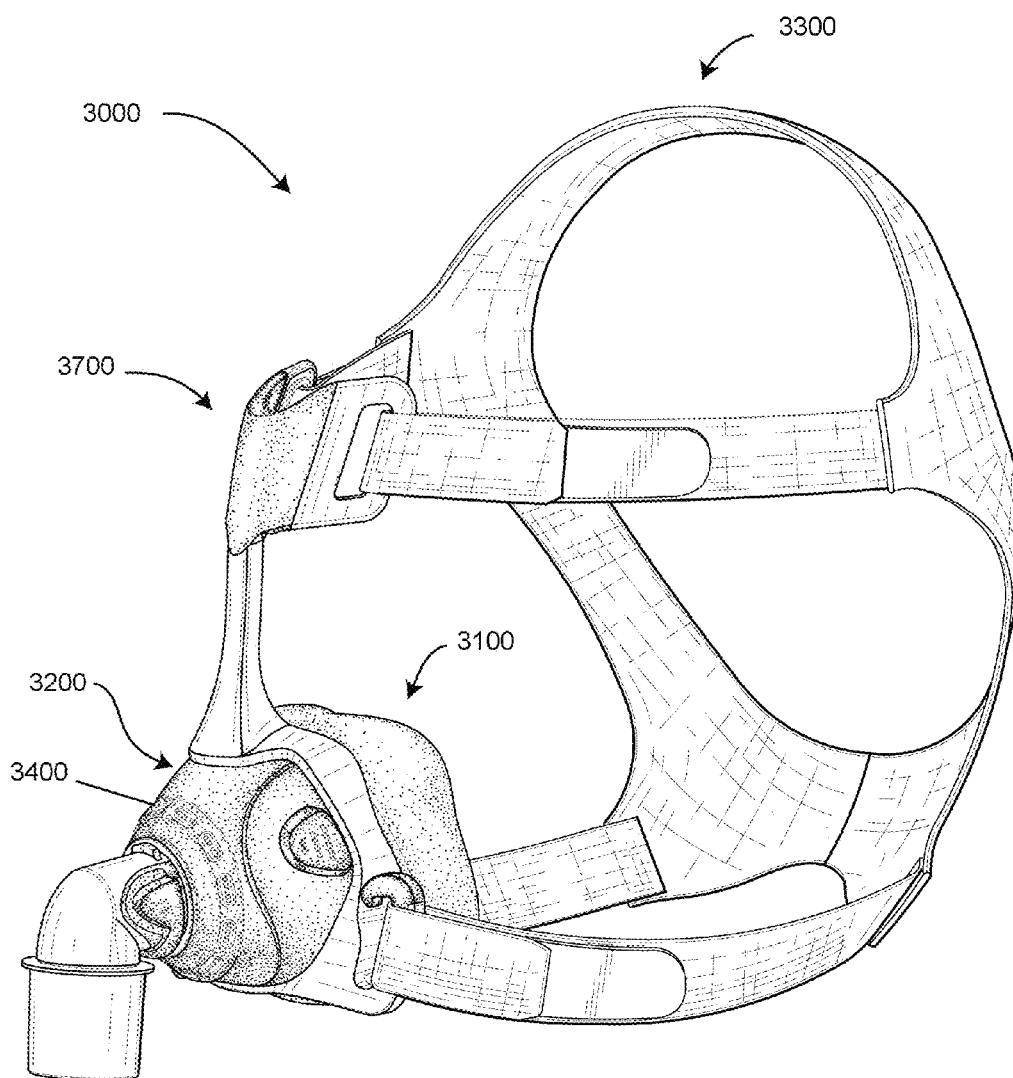


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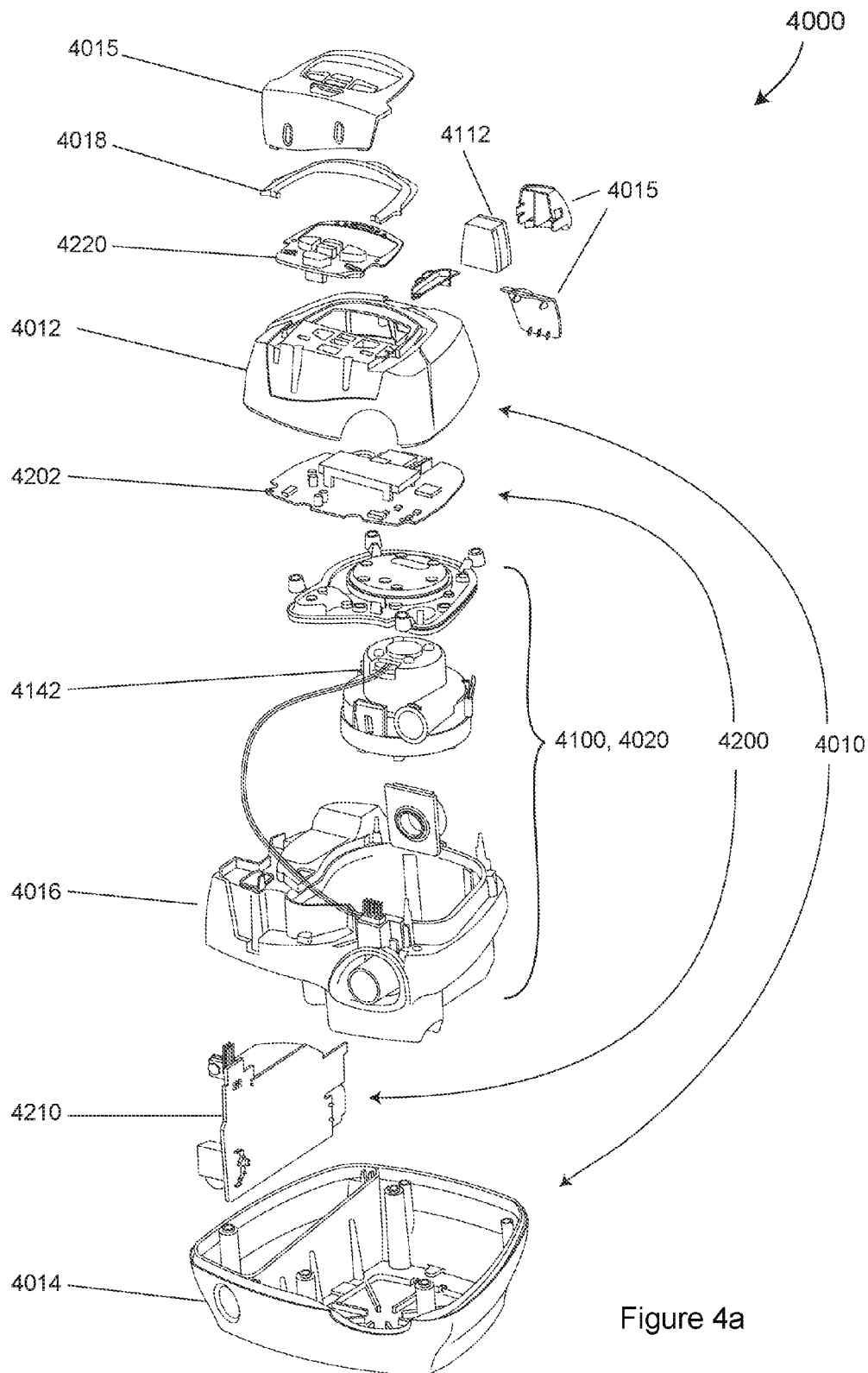


Figure 4a

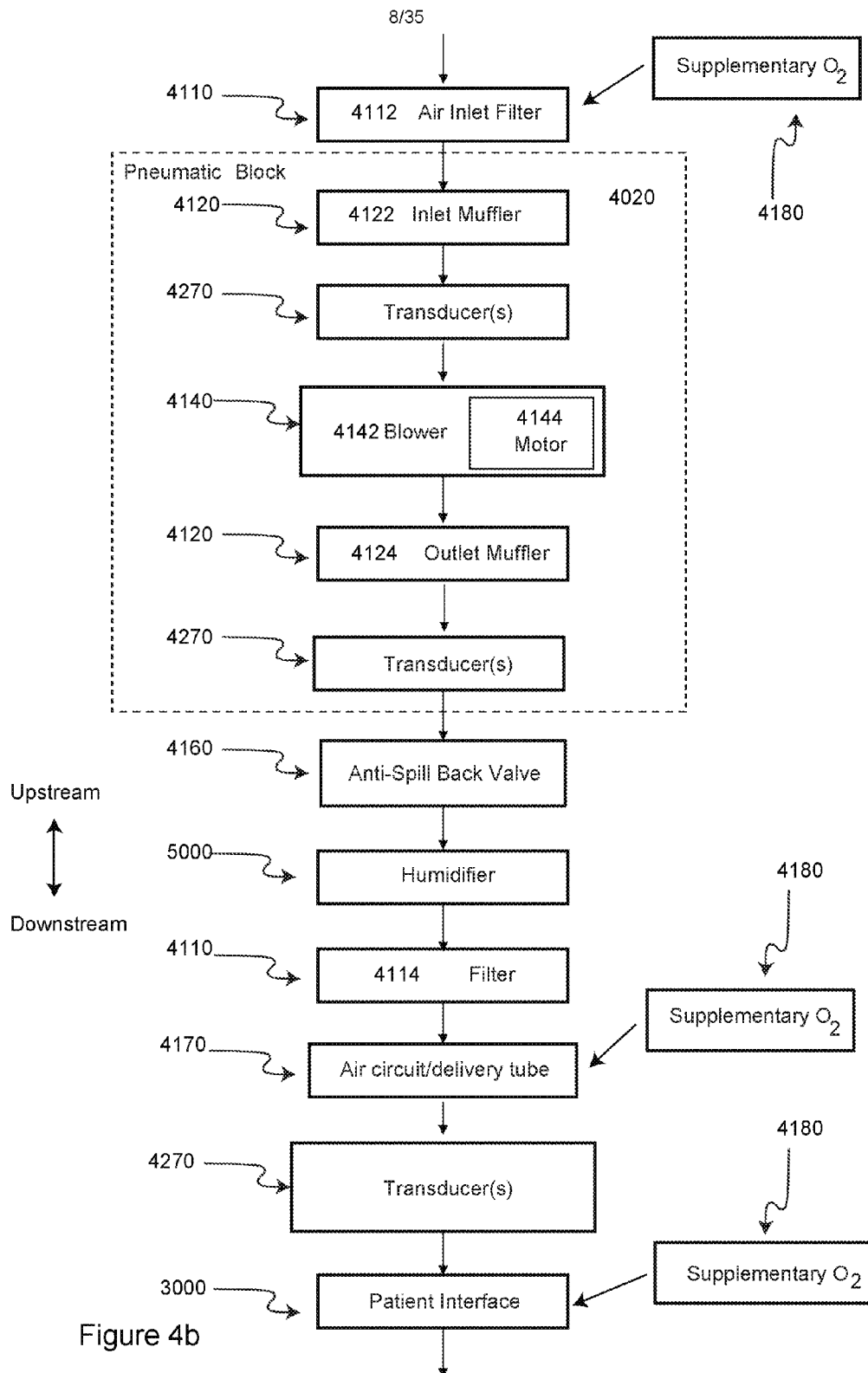


Figure 4b

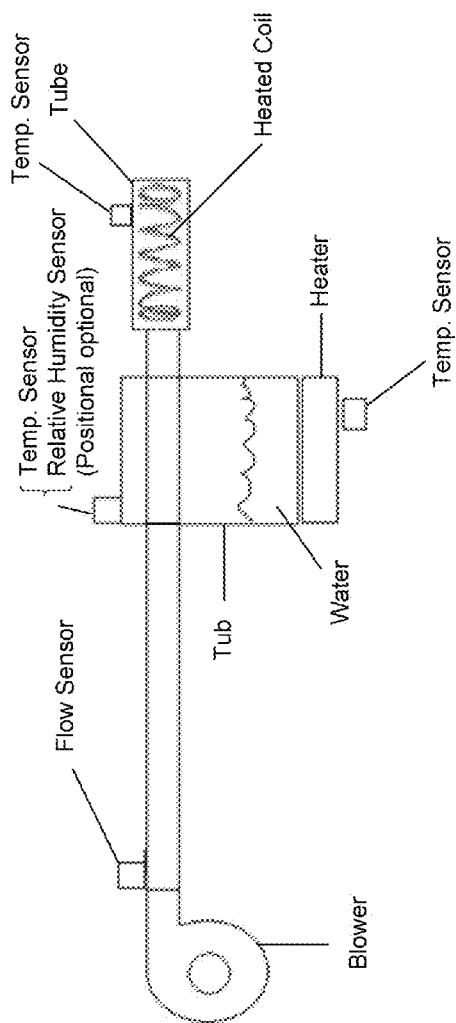


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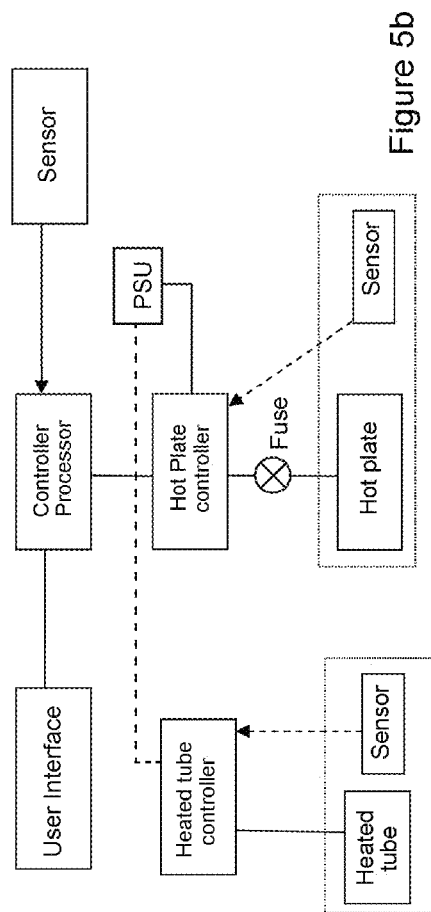
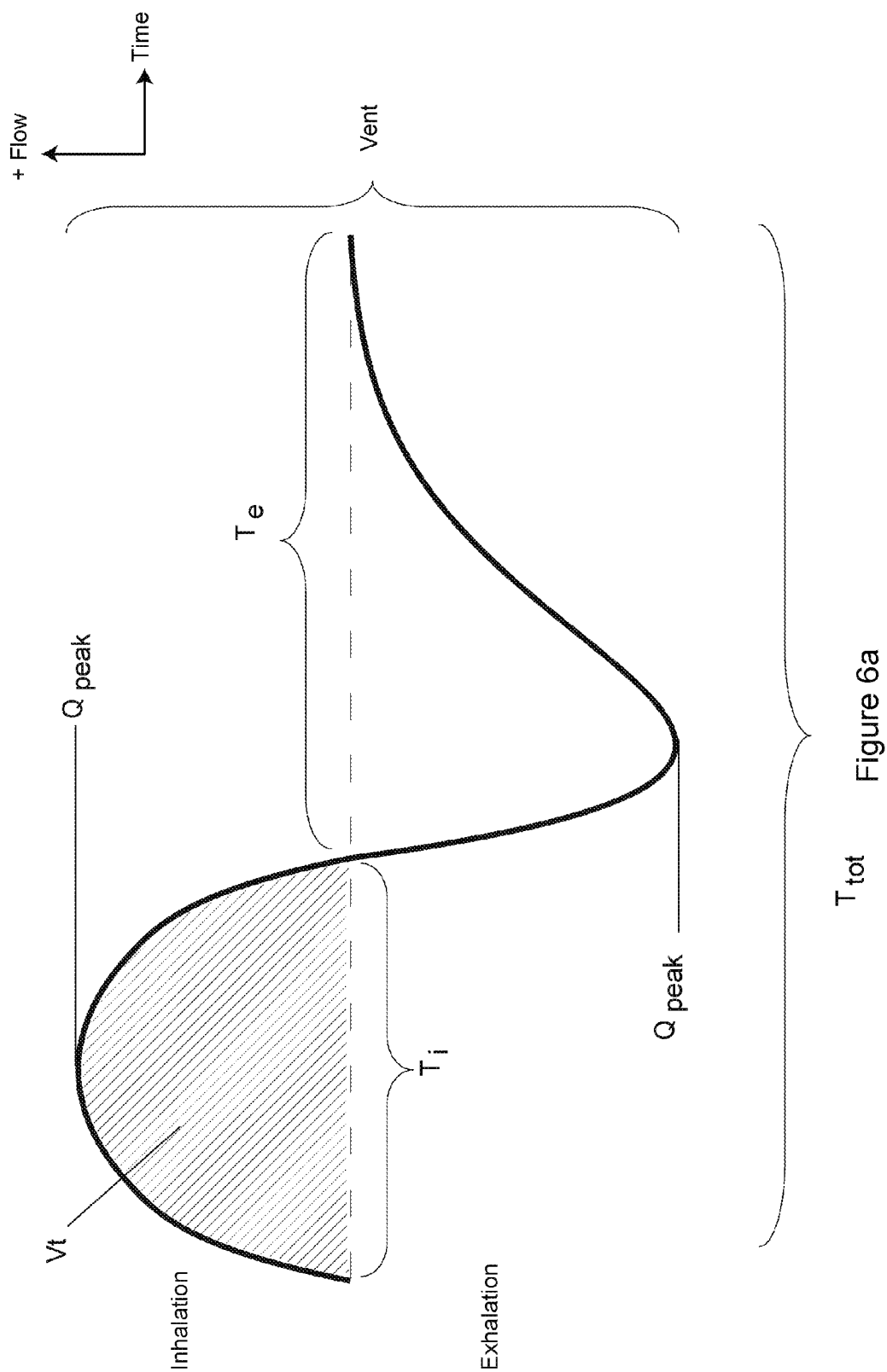


Figure 5b



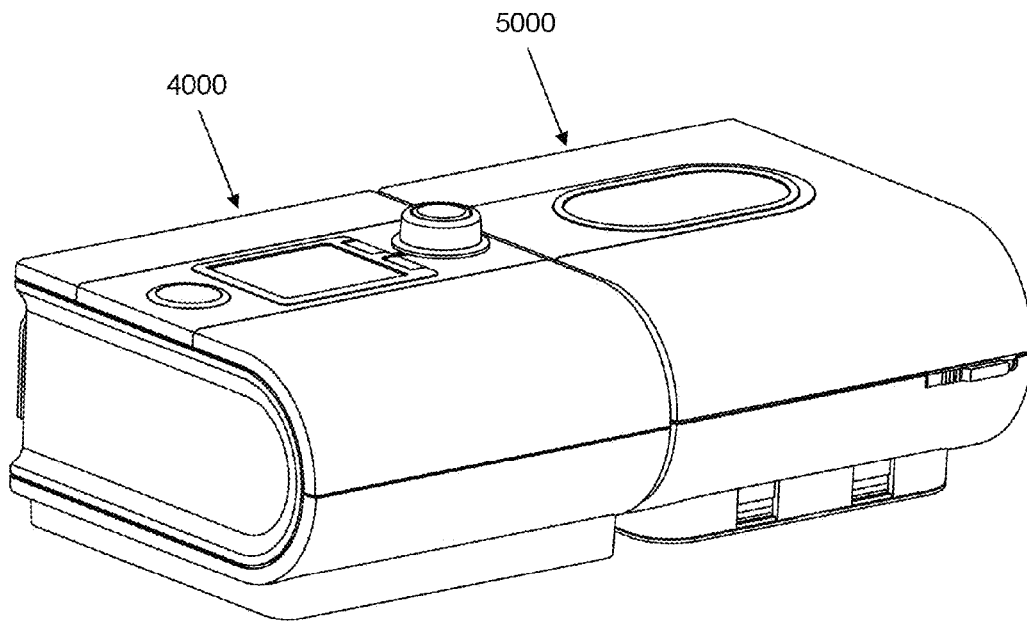


Figure 7
(Prior Art)

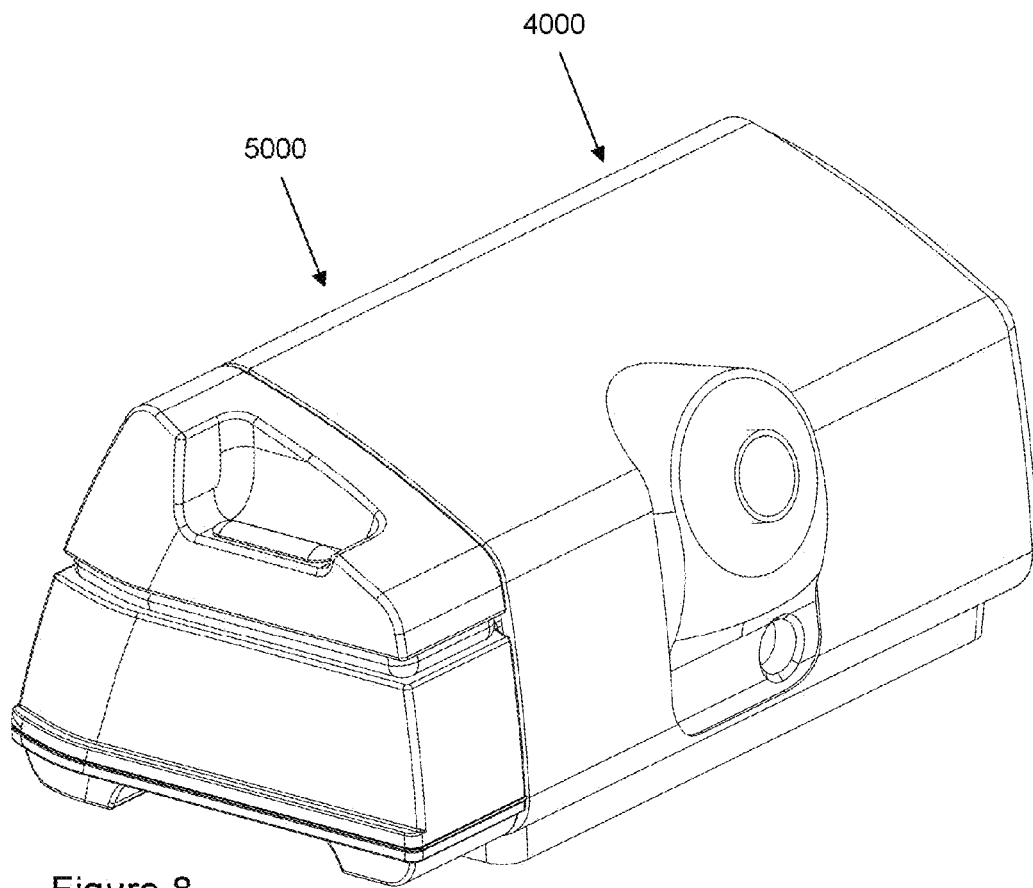


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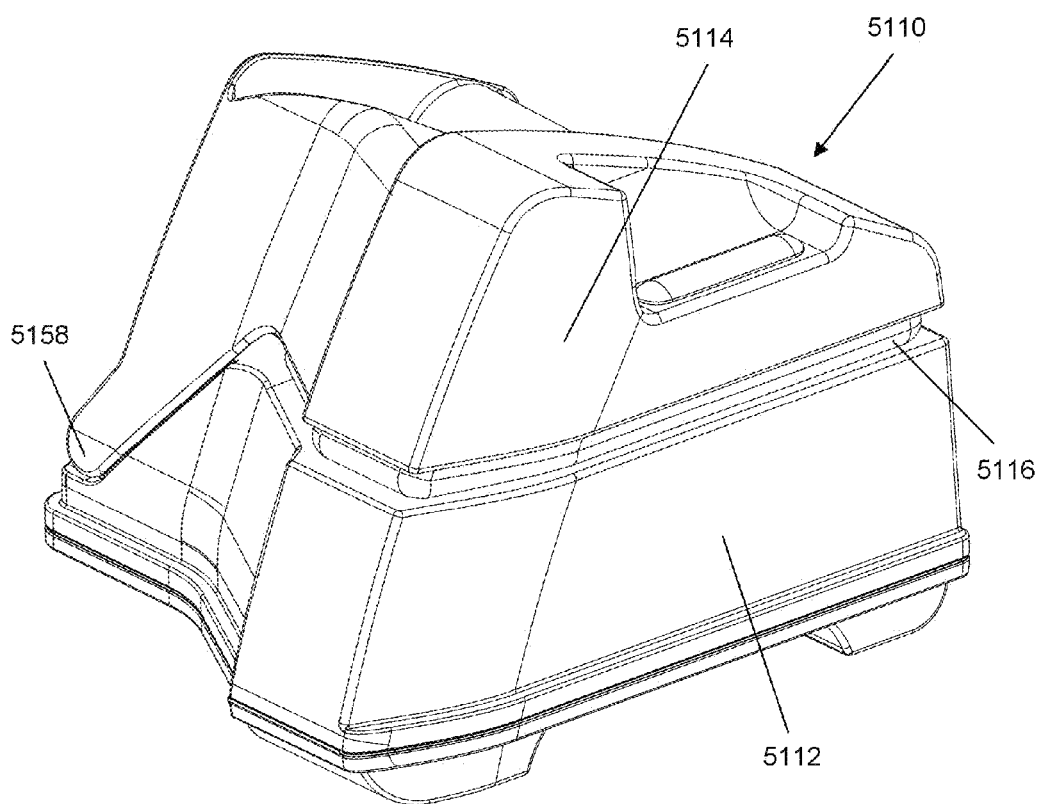


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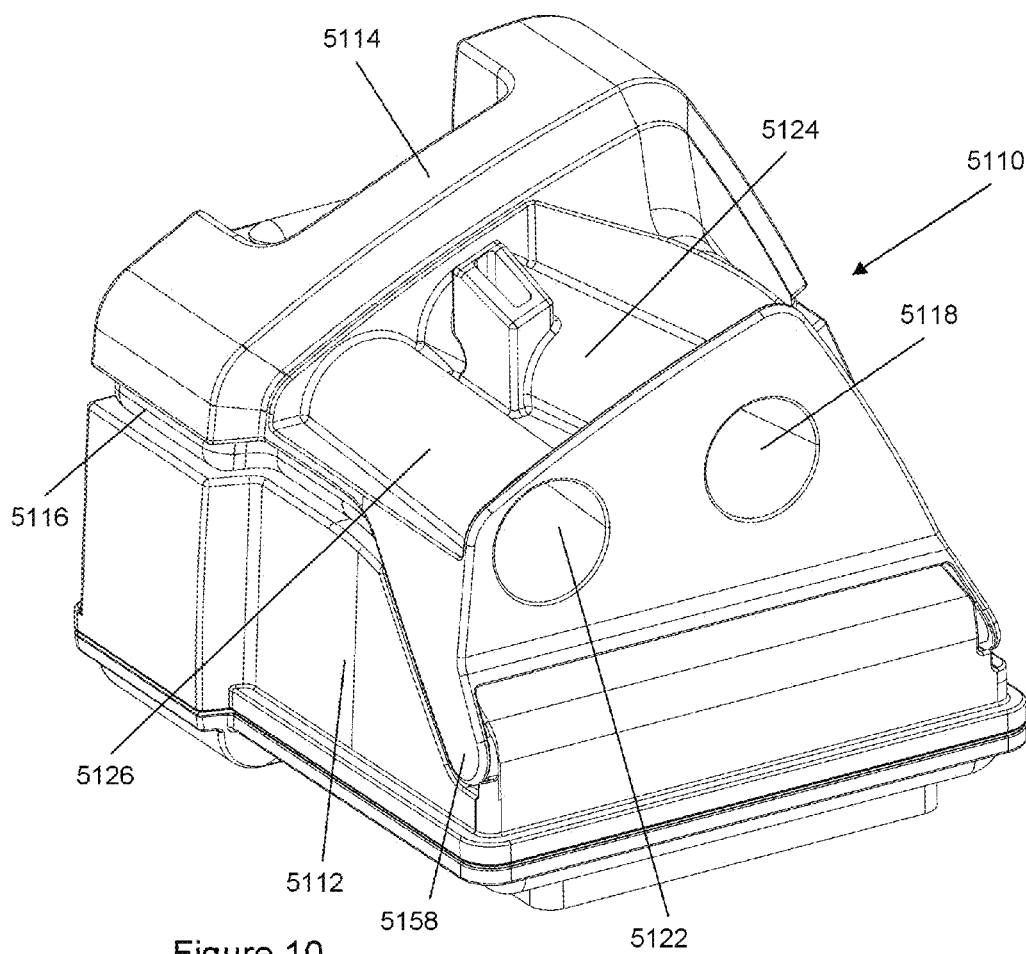


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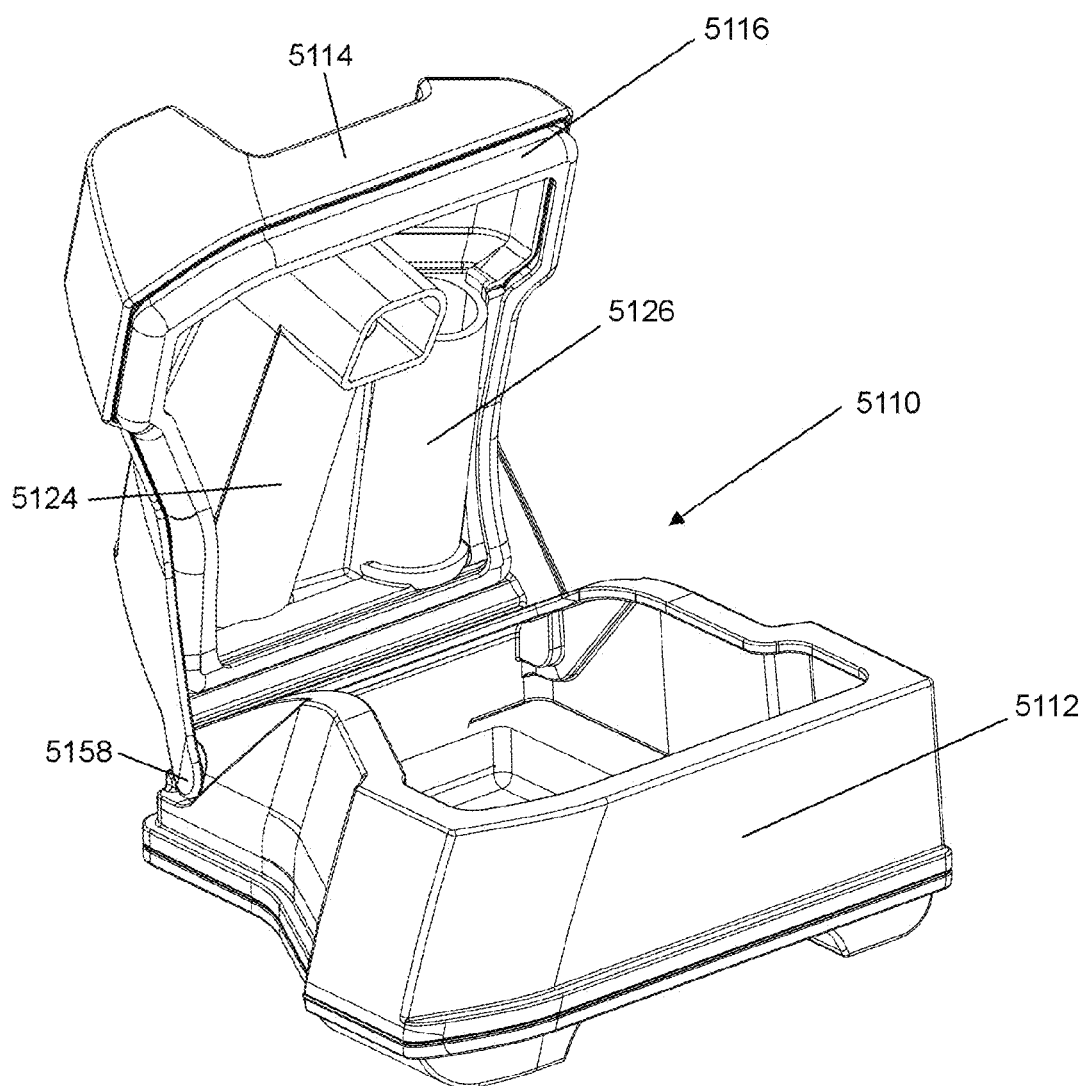


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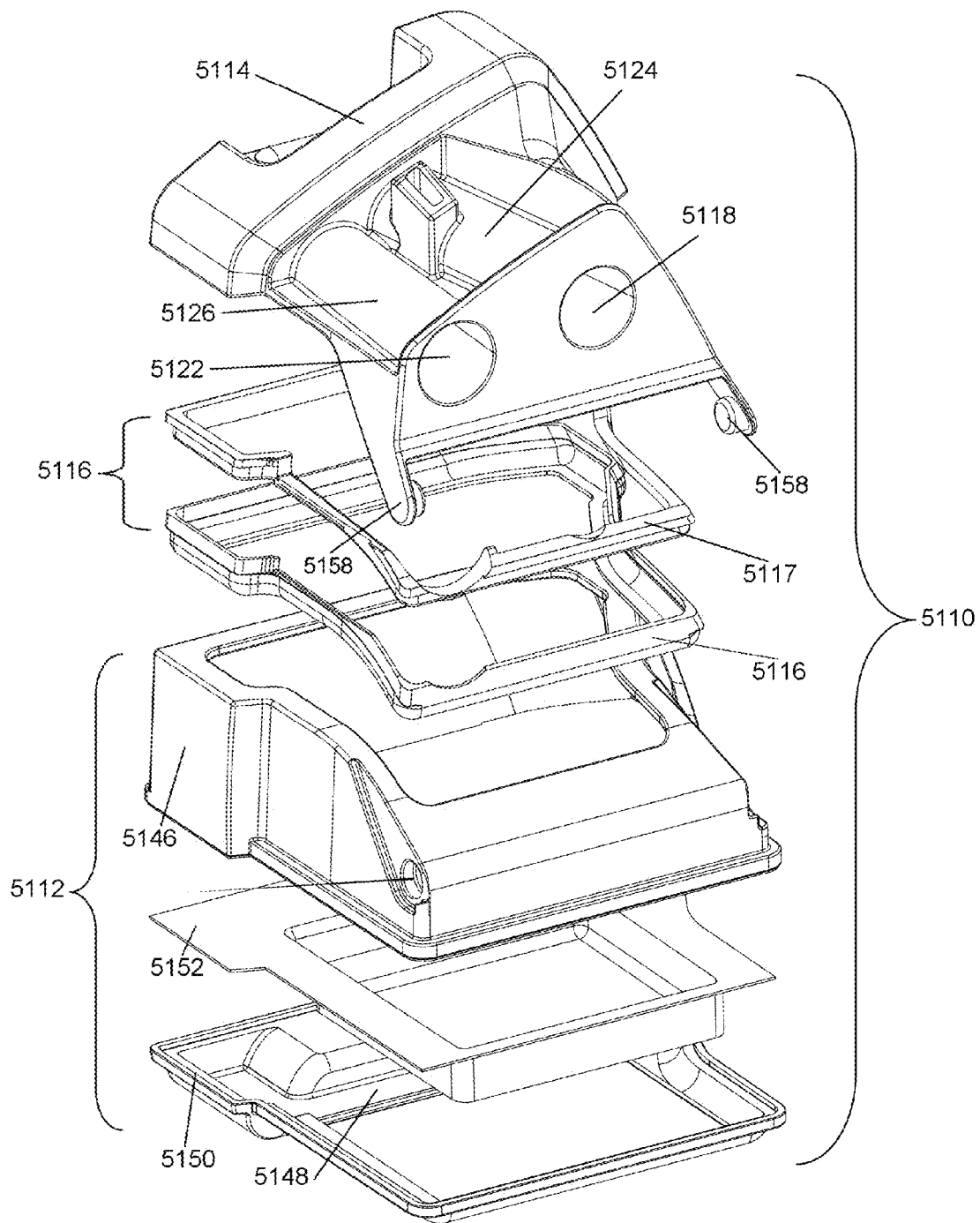


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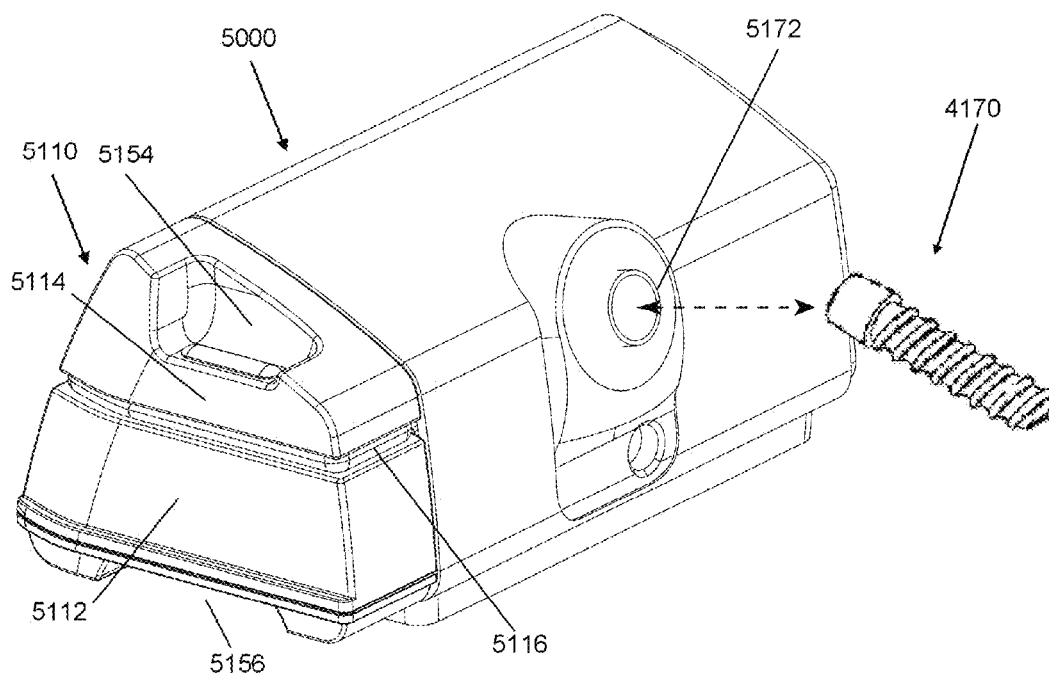


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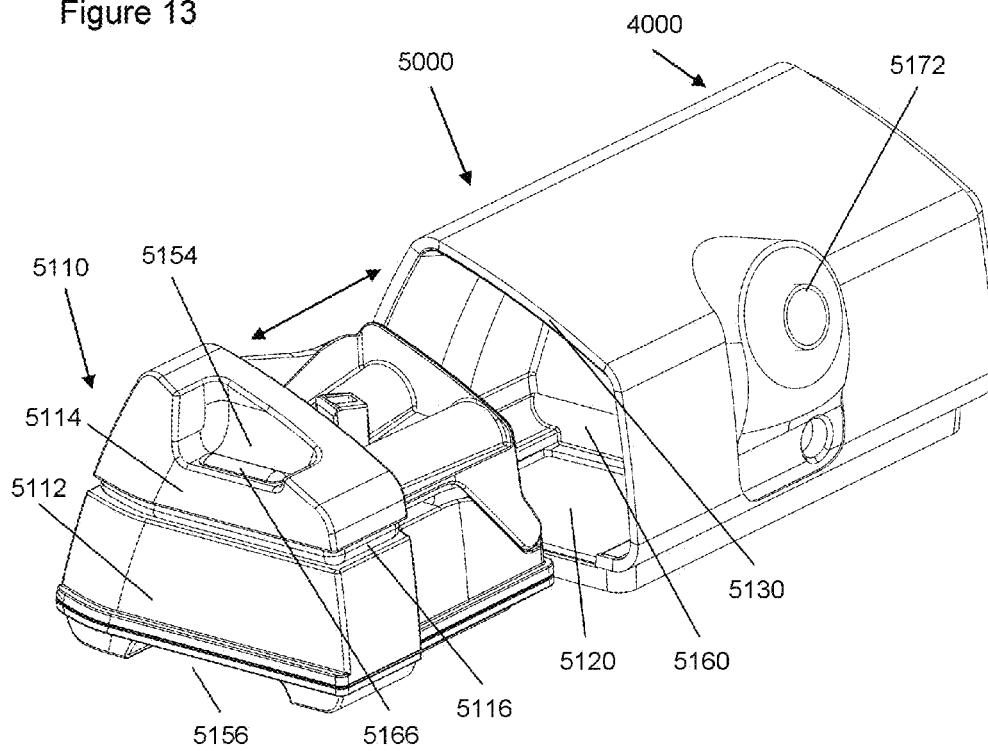


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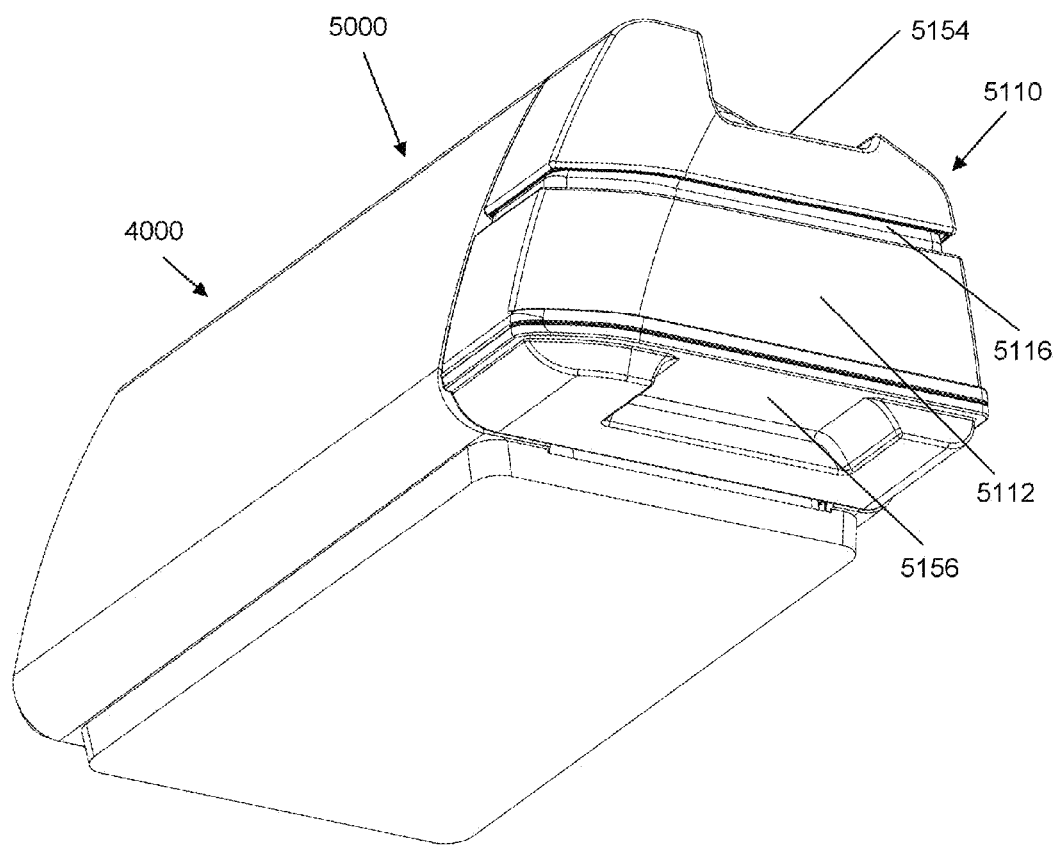


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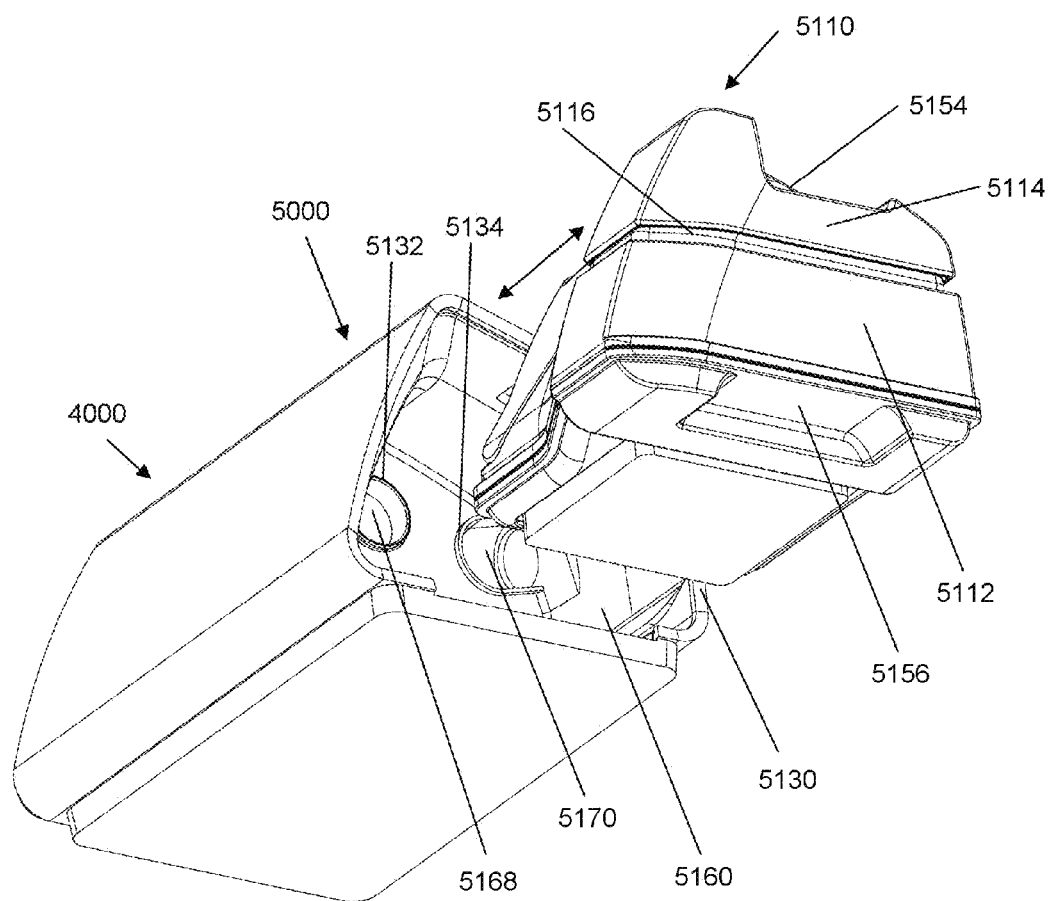


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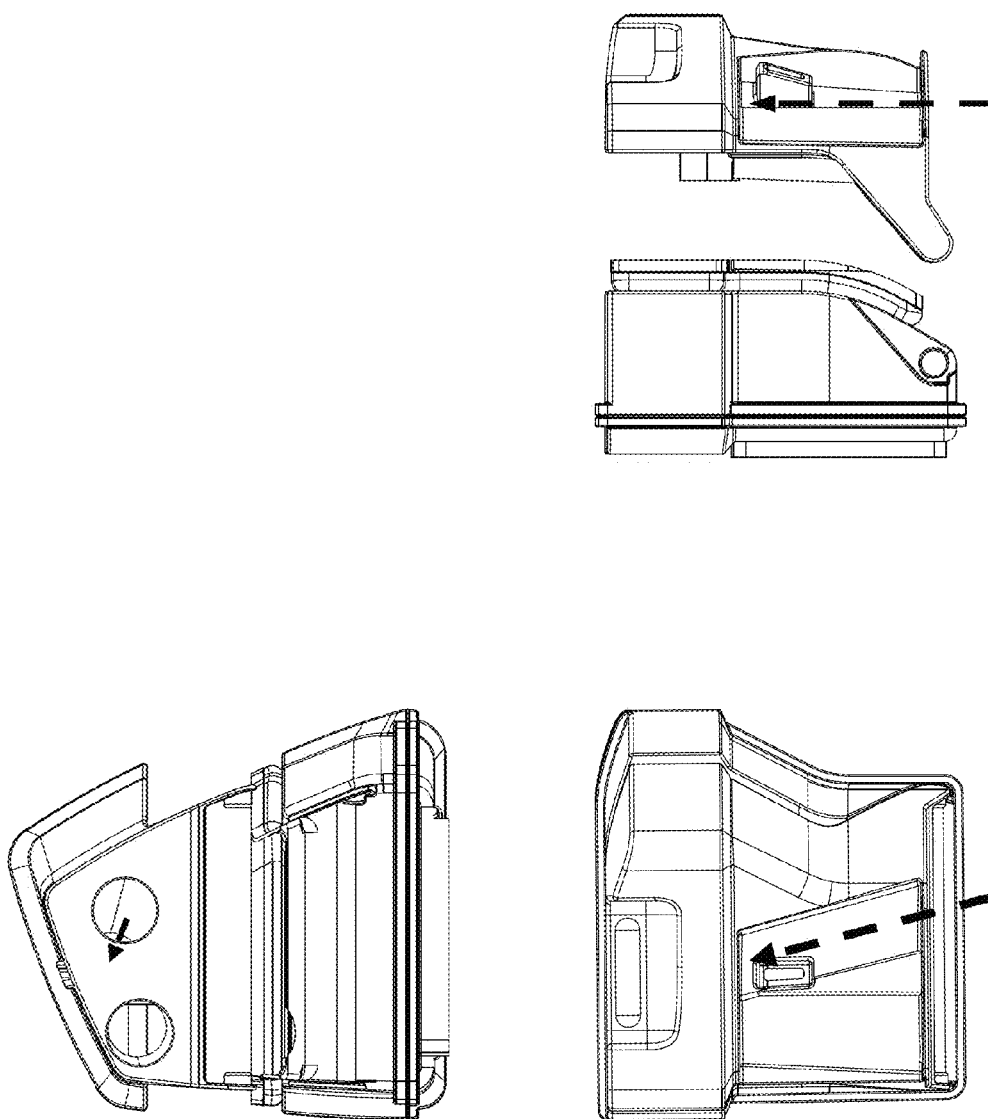


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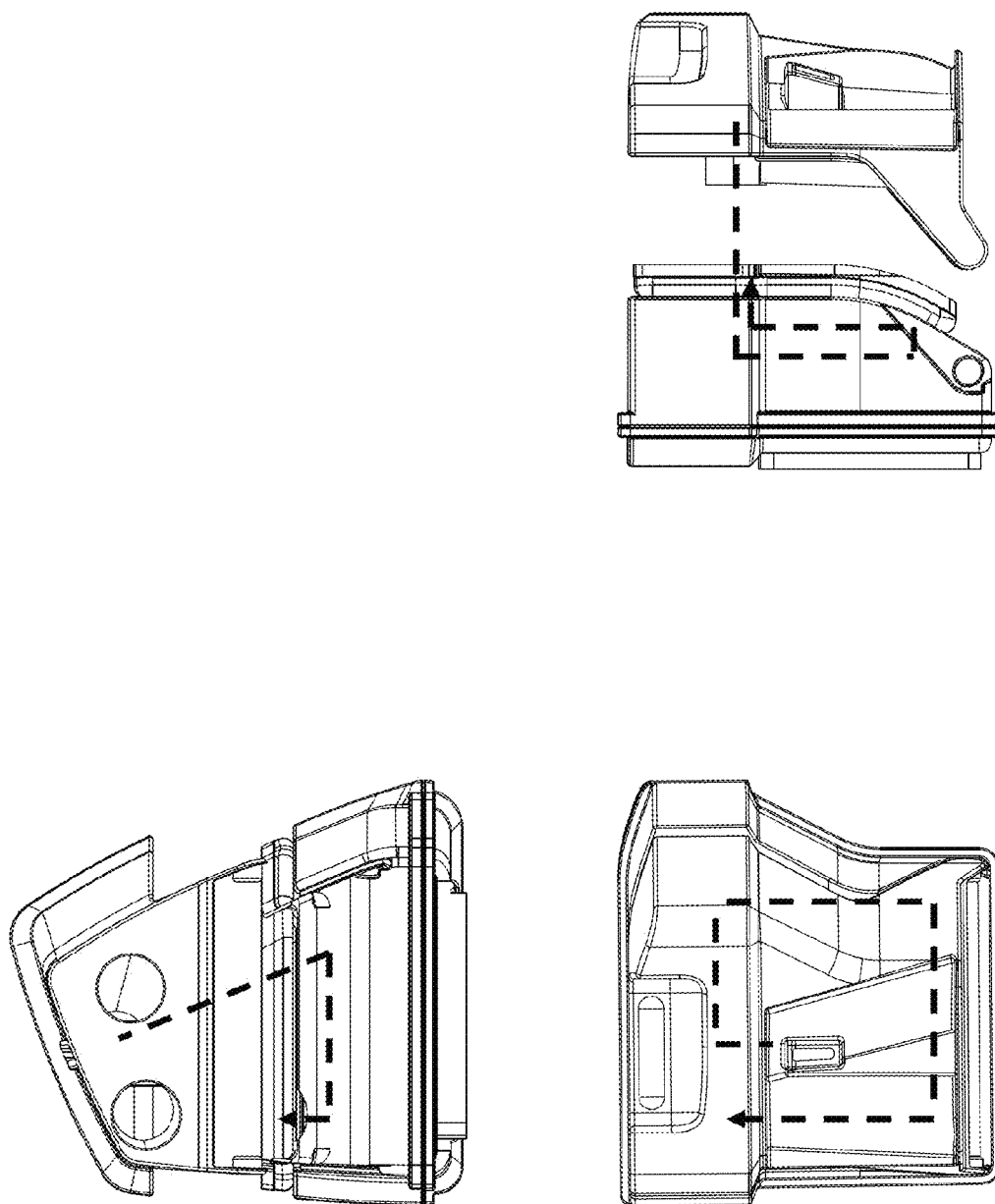


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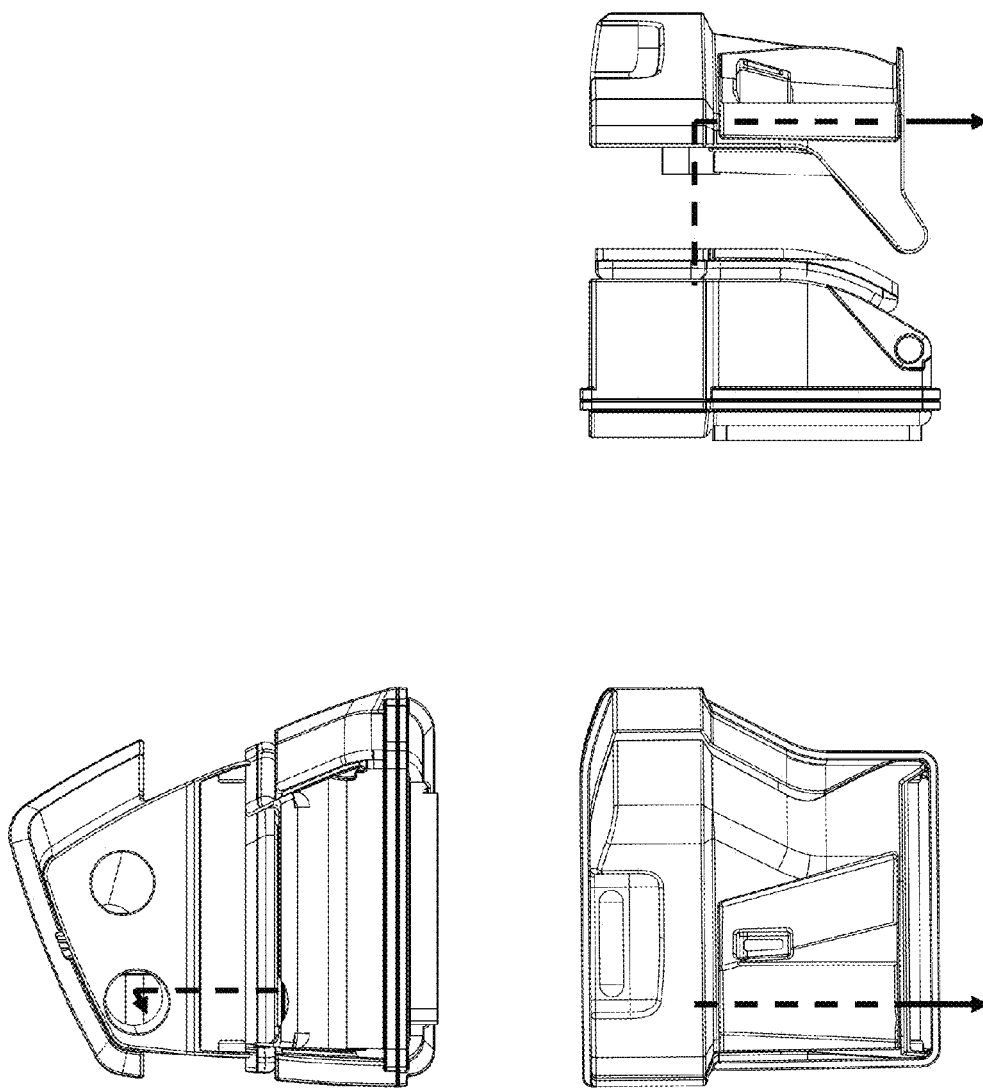


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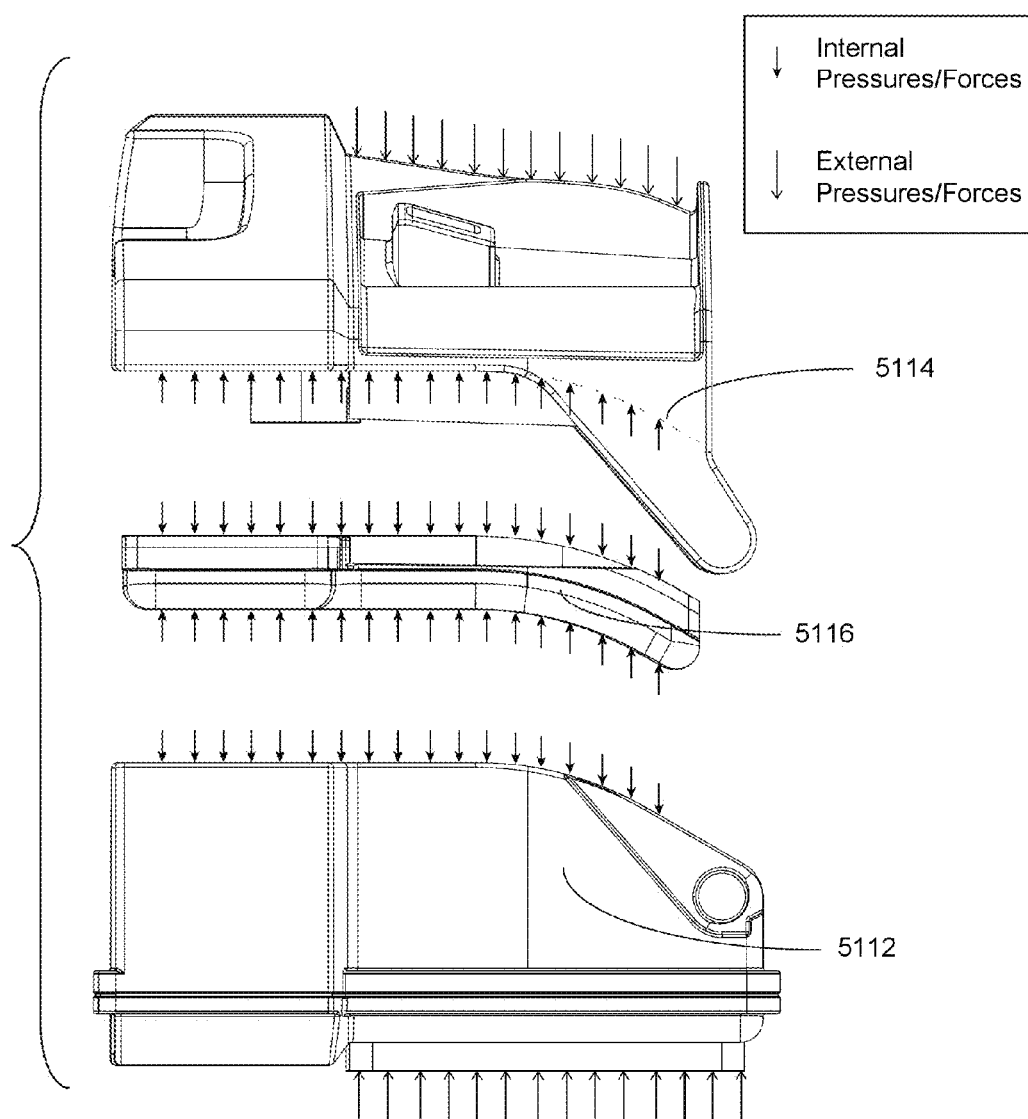


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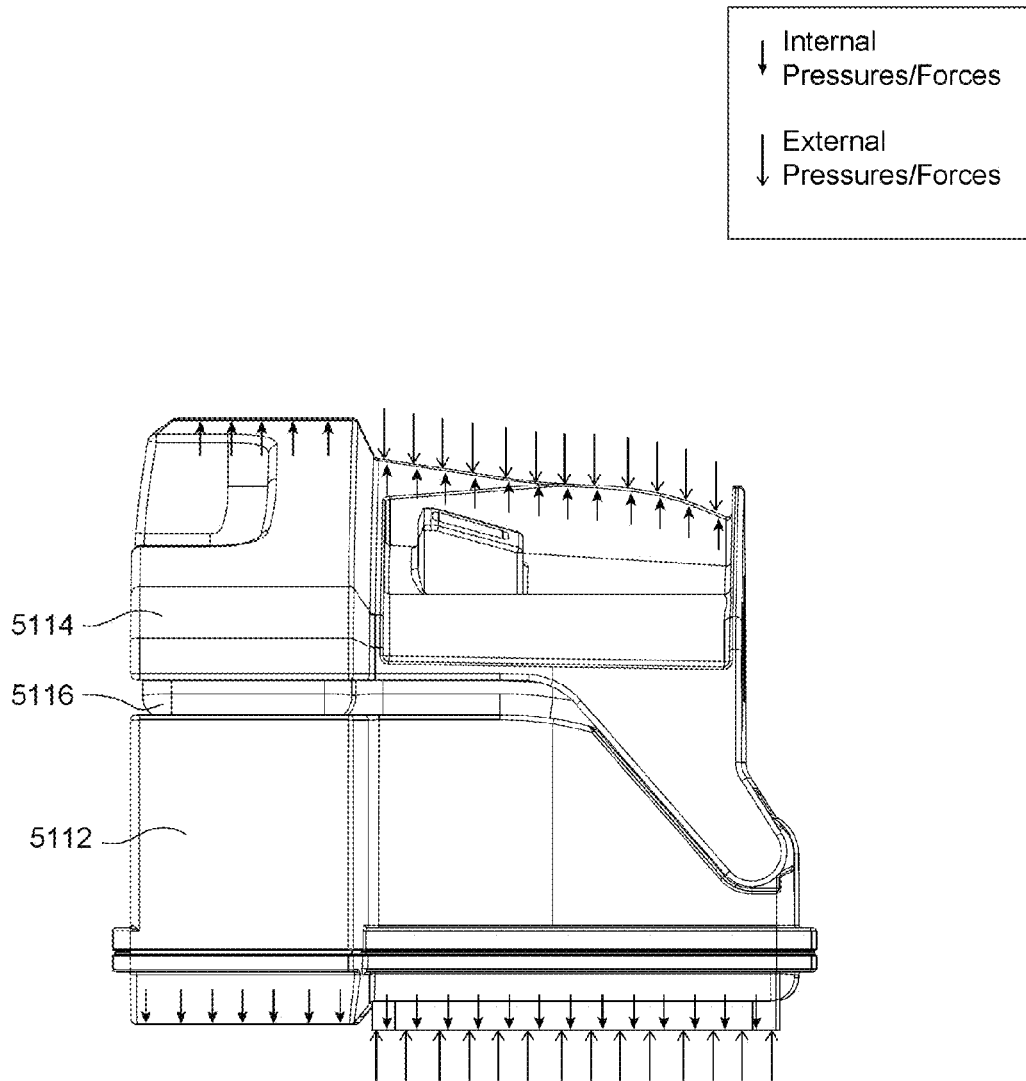


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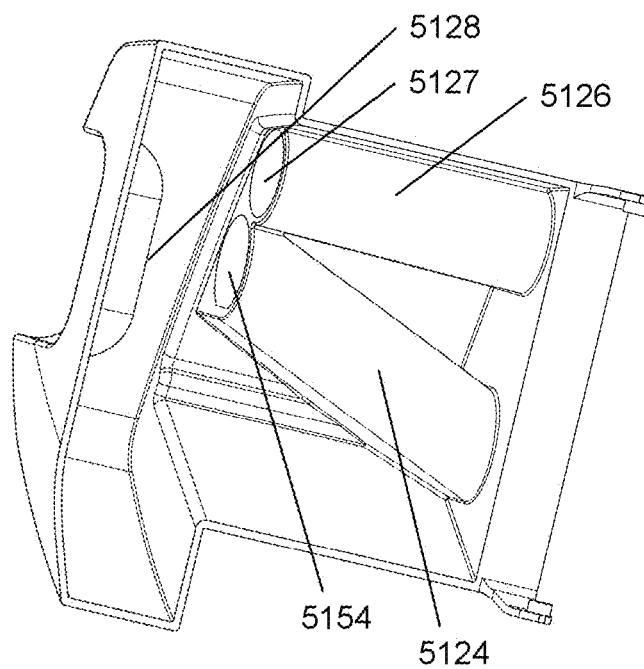


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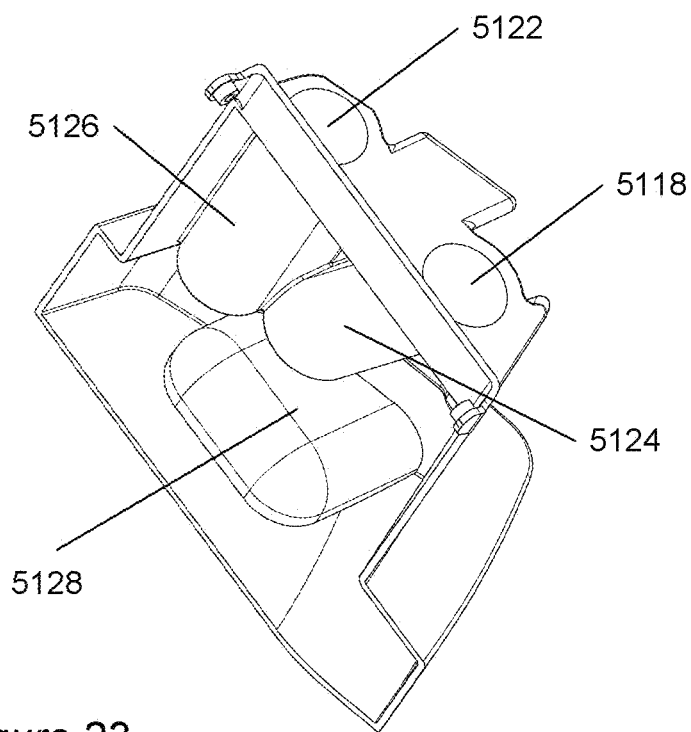


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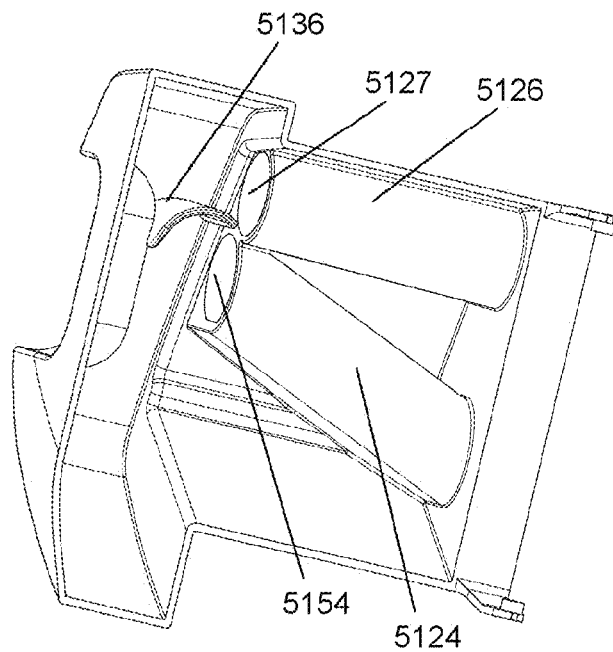


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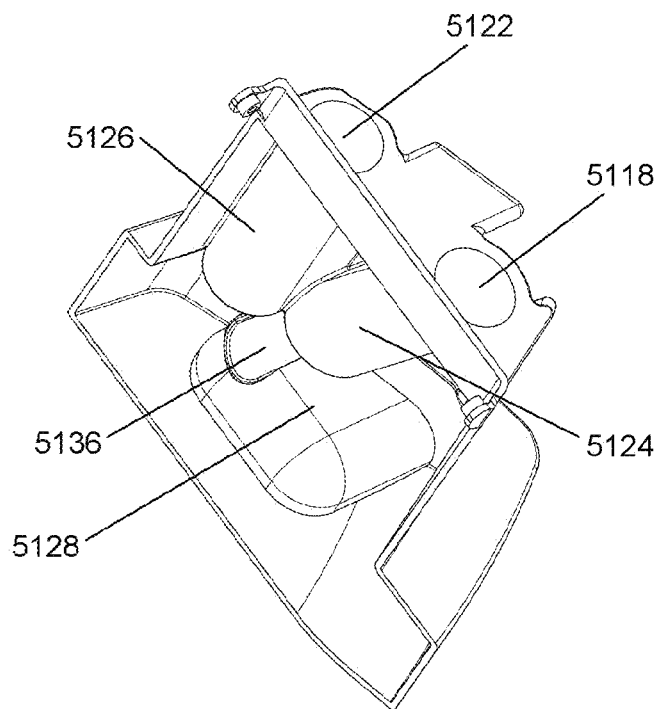


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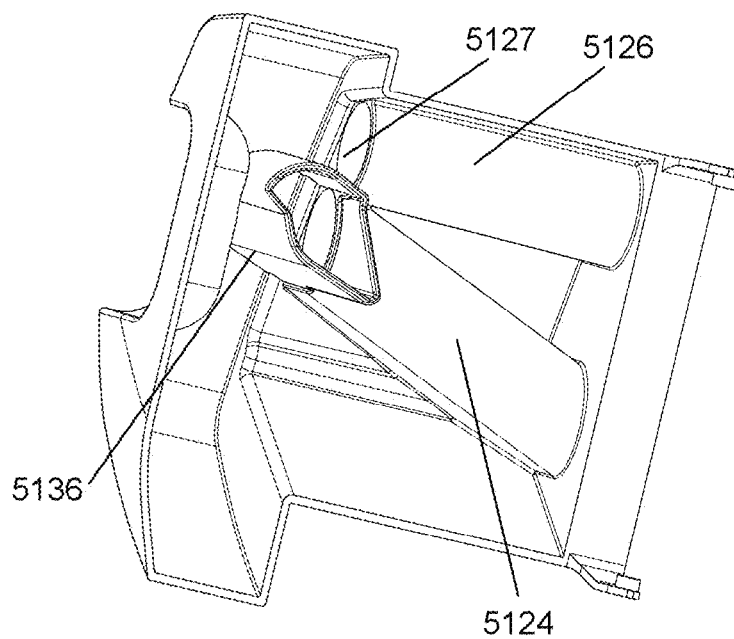


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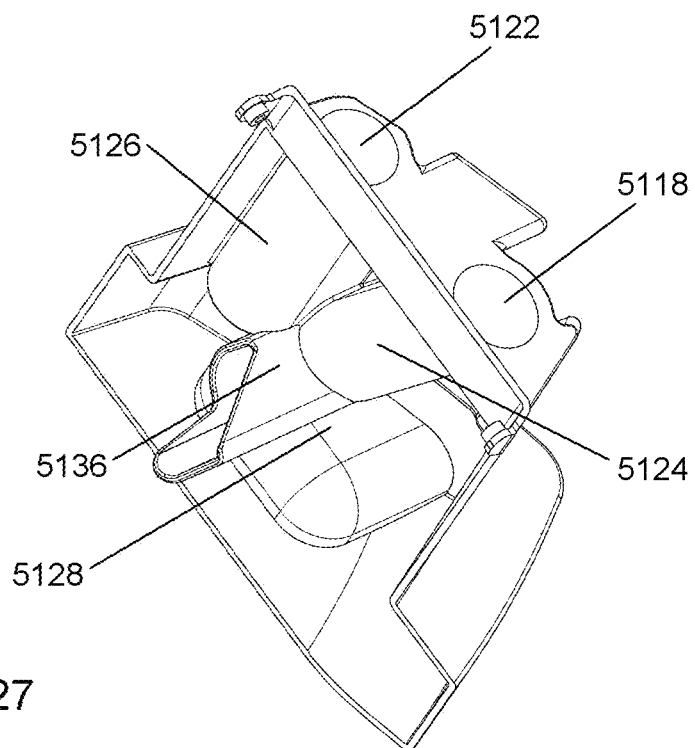


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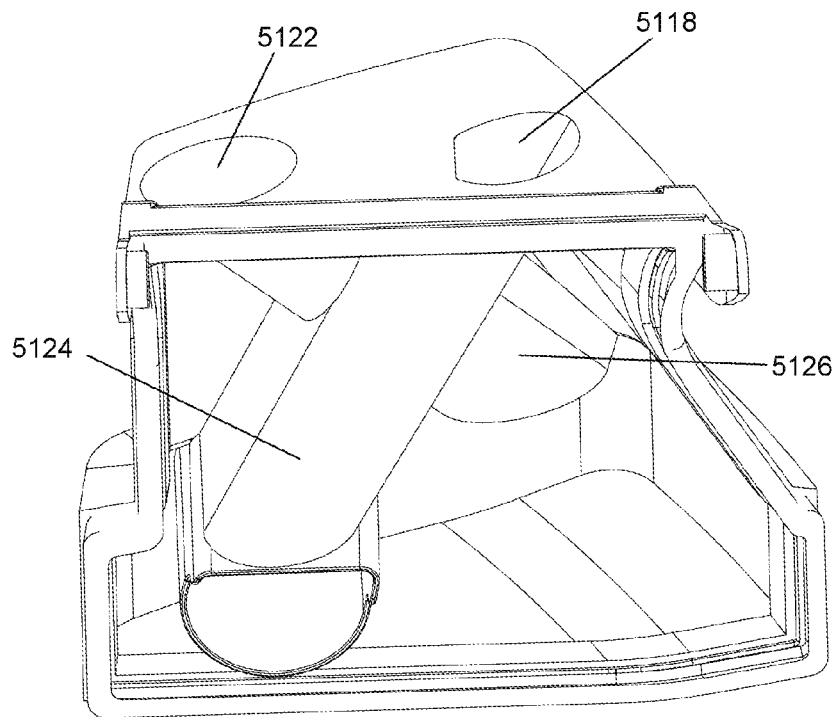


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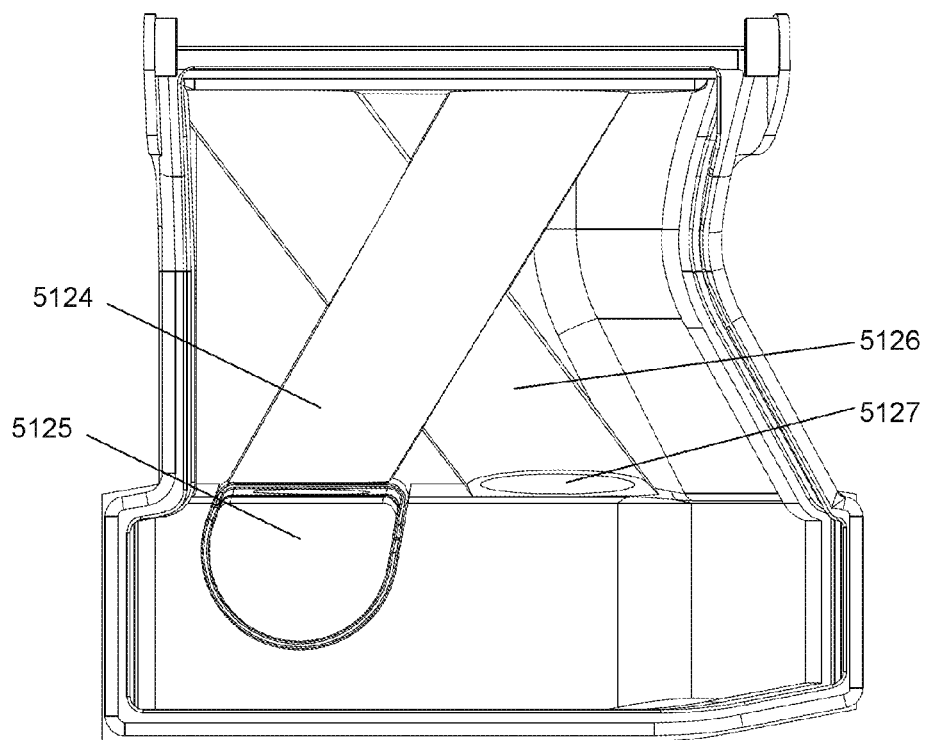


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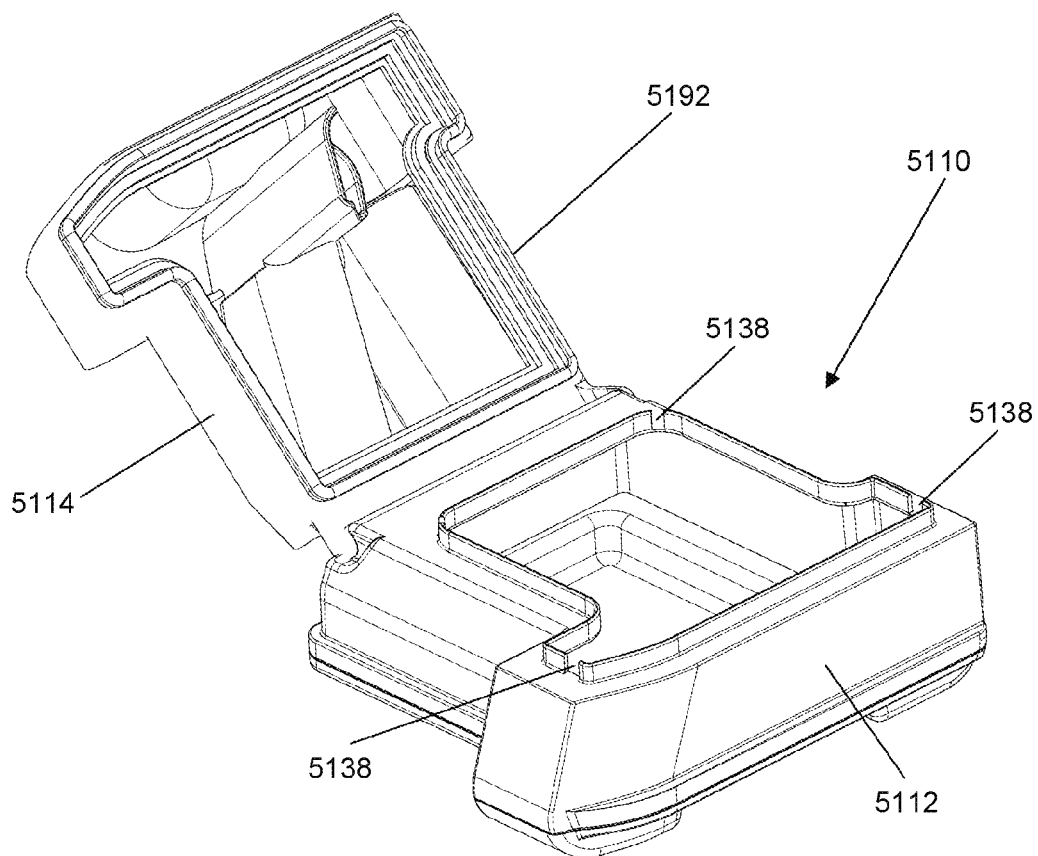


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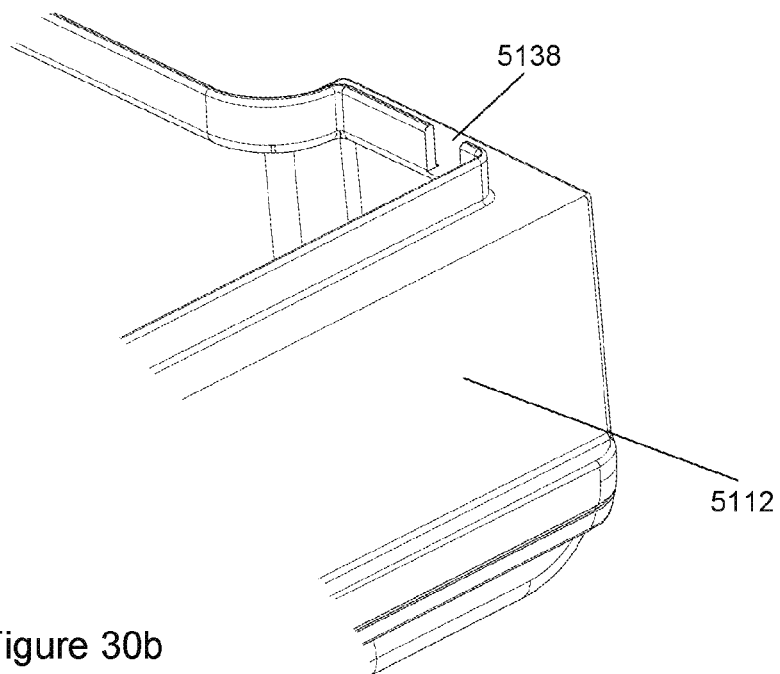


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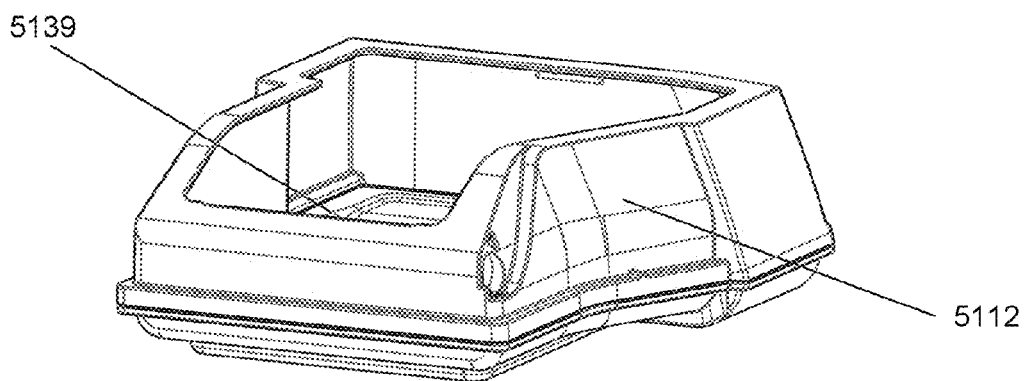


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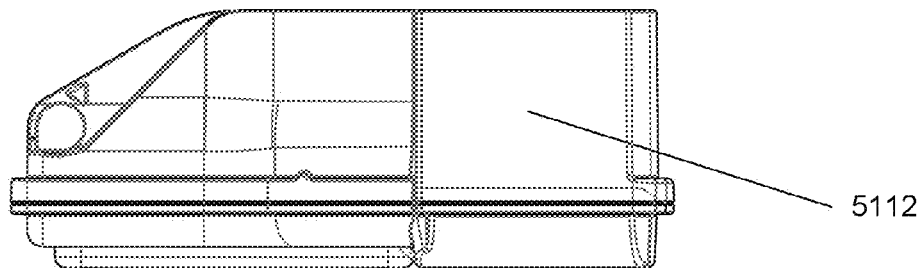


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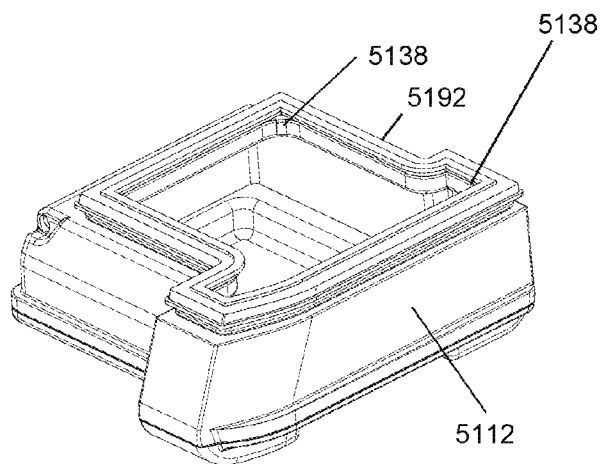


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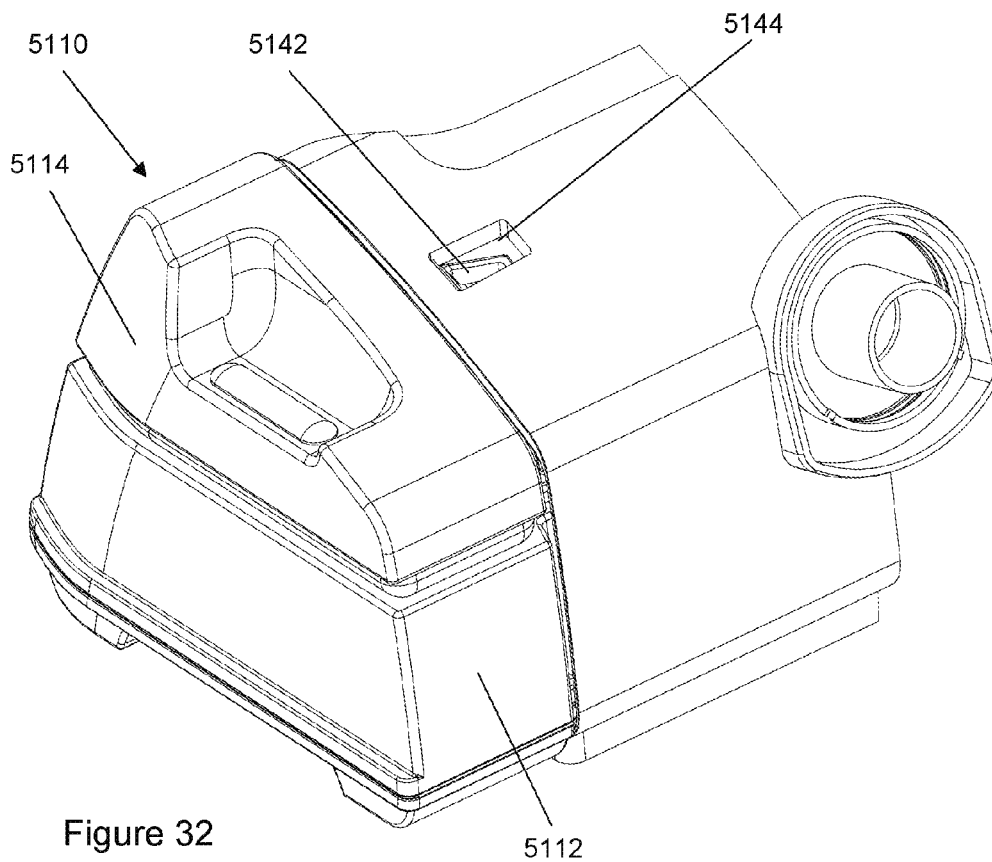


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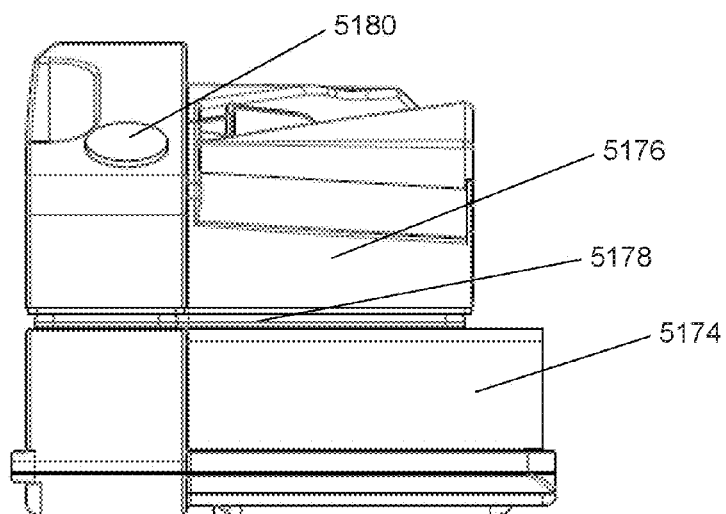
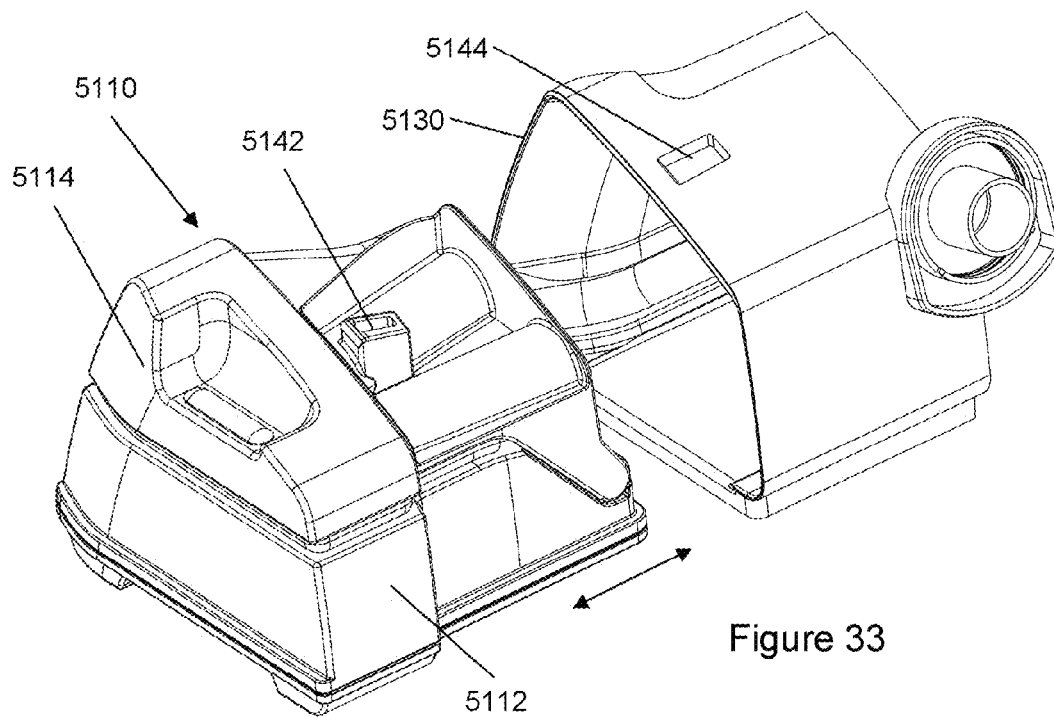


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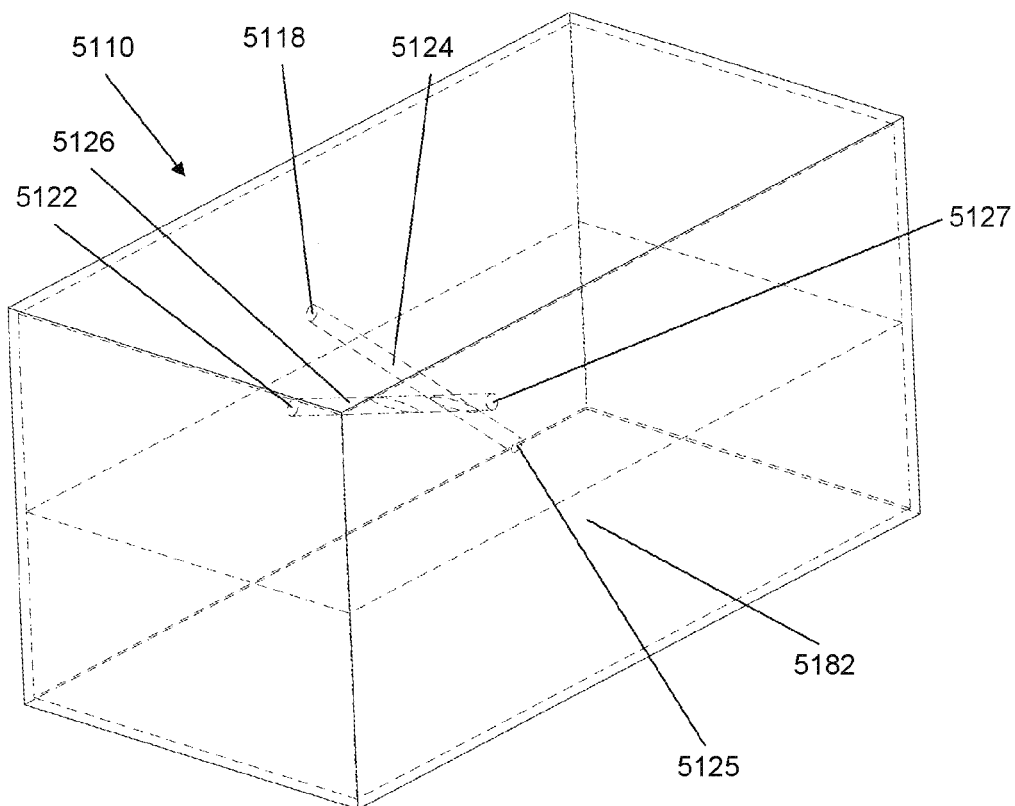


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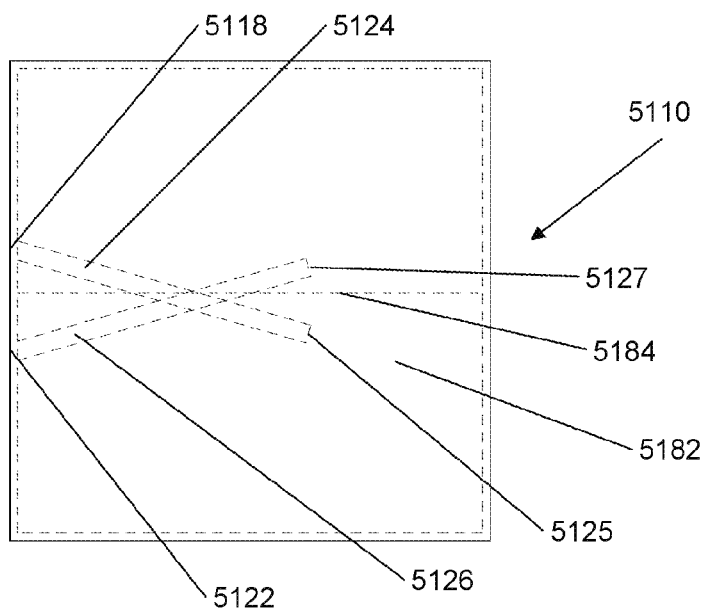


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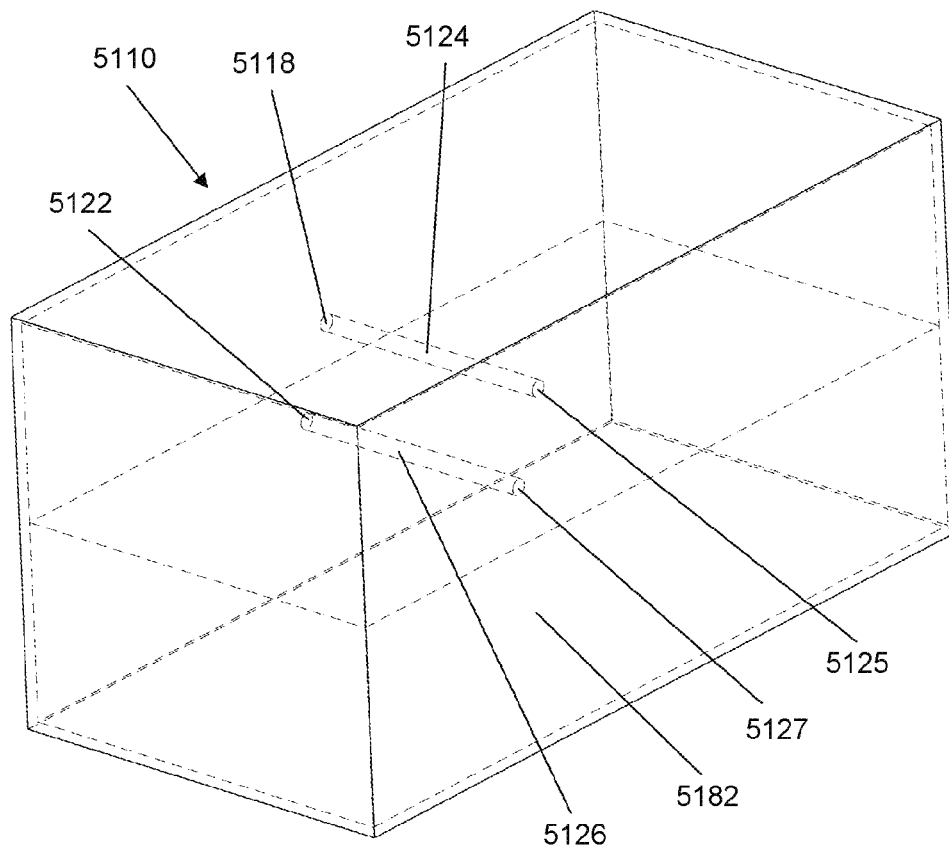


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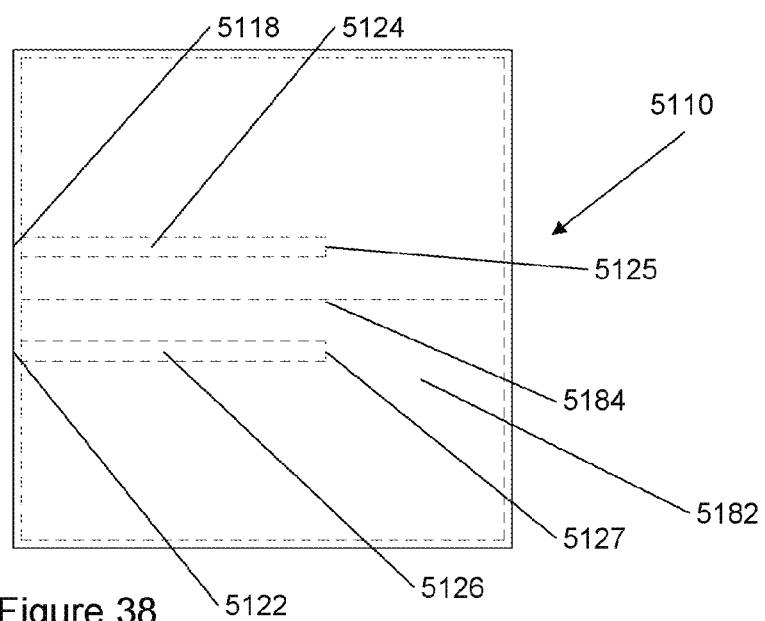


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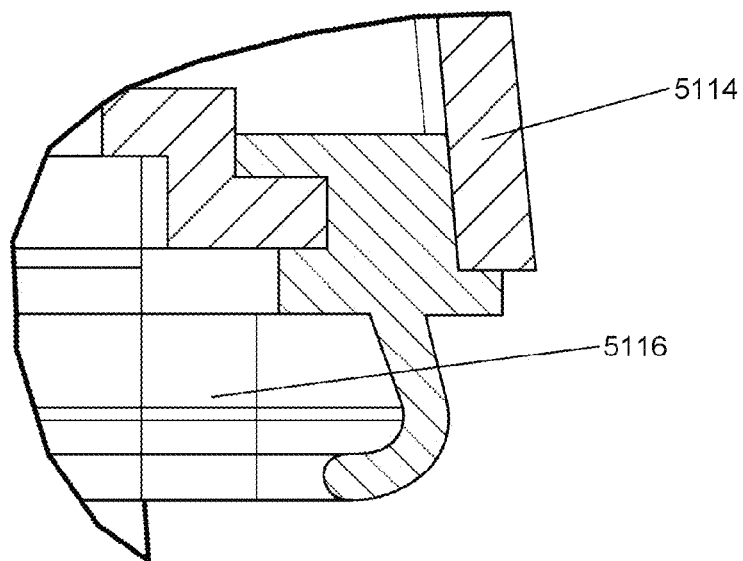


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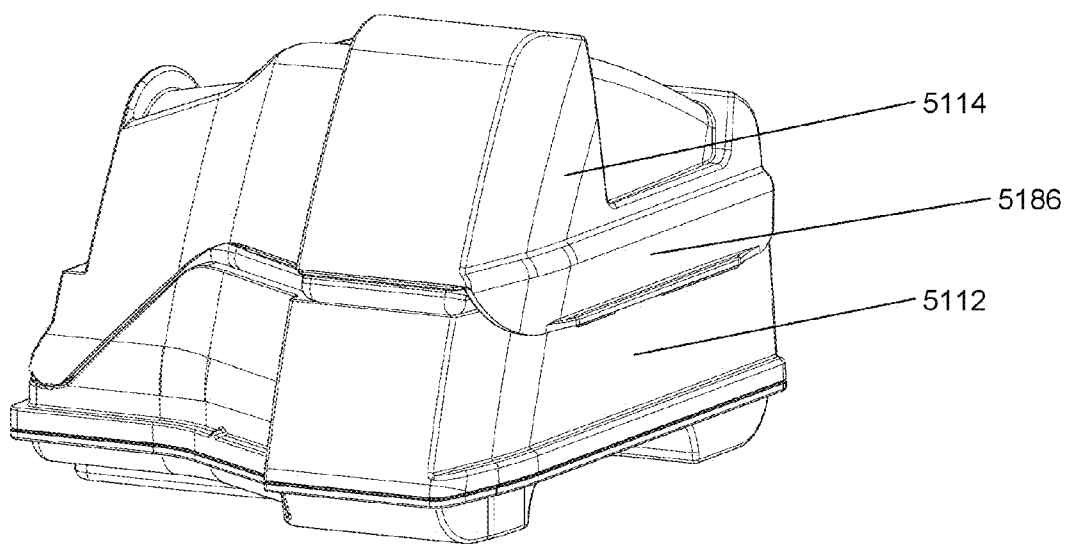


Figure 40

1

HUMIDIFIER RESERVOIR**1 CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of Australian Provisional Application No. 2013900901, filed Mar. 15, 2013, which is incorporated herein by reference in its entirety.

2 BACKGROUND OF THE INVENTION**2.1 (1) Field of the Invention**

The present technology relates to one or more of the diagnosis, treatment and amelioration of respiratory disorders, and to procedures to prevent respiratory disorders. In particular, the present technology relates to medical devices, and their use for treating respiratory disorders and for preventing respiratory disorders.

2.2 (2) Description of the Related Art

The respiratory system of the body facilitates gas exchange. The nose and mouth form the entrance to the airways of a patient.

The airways consist of a series of branching tubes, which become narrower, shorter and more numerous as they penetrate deeper into the lung. The prime function of the lung is gas exchange, allowing oxygen to move from the air into the venous blood and carbon dioxide to move out. The trachea divides into right and left main bronchi, which further divide eventually into terminal bronchioles. The bronchi make up the conducting airways, and do not take part in gas exchange. Further divisions of the airways lead to the respiratory bronchioles, and eventually to the alveoli. The alveolated region of the lung is where the gas exchange takes place, and is referred to as the respiratory zone. See West, *Respiratory Physiology—the essentials*.

A range of respiratory disorders exist.

Obstructive Sleep Apnoea (OSA), a form of Sleep Disordered Breathing (SDB), is characterized by occlusion of the upper air passage during sleep. It results from a combination of an abnormally small upper airway and the normal loss of muscle tone in the region of the tongue, soft palate and posterior oropharyngeal wall during sleep. The condition causes the affected patient to stop breathing for periods typically of 30 to 120 seconds duration, sometimes 200 to 300 times per night. It often causes excessive daytime somnolence, and it may cause cardiovascular disease and brain damage. The syndrome is a common disorder, particularly in middle aged overweight males, although a person affected may have no awareness of the problem. See U.S. Pat. No. 4,944,310 (Sullivan).

Cheyne-Stokes Respiration (CSR) is a disorder of a patient's respiratory controller in which there are rhythmic alternating periods of waxing and waning ventilation, causing repetitive de-oxygenation and re-oxygenation of the arterial blood. It is possible that CSR is harmful because of the repetitive hypoxia. In some patients CSR is associated with repetitive arousal from sleep, which causes severe sleep disruption, increased sympathetic activity, and increased afterload. See U.S. Pat. No. 6,532,959 (Berthon-Jones).

Obesity Hyperventilation Syndrome (OHS) is defined as the combination of severe obesity and awake chronic hypercapnia, in the absence of other known causes for hypoventilation. Symptoms include dyspnea, morning headache and excessive daytime sleepiness.

Chronic Obstructive Pulmonary Disease (COPD) encompasses any of a group of lower airway diseases that have certain characteristics in common. These include increased

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resistance to air movement, extended expiratory phase of respiration, and loss of the normal elasticity of the lung. Examples of COPD are emphysema and chronic bronchitis. COPD is caused by chronic tobacco smoking (primary risk factor), occupational exposures, air pollution and genetic factors. Symptoms include: dyspnoea on exertion, chronic cough and sputum production.

Neuromuscular Disease (NMD) is a broad term that encompasses many diseases and ailments that impair the functioning of the muscles either directly via intrinsic muscle pathology, or indirectly via nerve pathology. Some NMD patients are characterised by progressive muscular impairment leading to loss of ambulation, being wheelchair-bound, swallowing difficulties, respiratory muscle weakness and, eventually, death from respiratory failure. Neuromuscular disorders can be divided into rapidly progressive and slowly progressive: (i) Rapidly progressive disorders: Characterised by muscle impairment that worsens over months and results in death within a few years (e.g. Amyotrophic lateral sclerosis (ALS) and Duchenne muscular dystrophy (DMD) in teenagers); (ii) Variable or slowly progressive disorders: Characterised by muscle impairment that worsens over years and only mildly reduces life expectancy (e.g. Limb girdle, Facioscapulohumeral and Myotonic muscular dystrophy). Symptoms of respiratory failure in NMD include: increasing generalised weakness, dysphagia, dyspnoea on exertion and at rest, fatigue, sleepiness, morning headache, and difficulties with concentration and mood changes.

Chest wall disorders are a group of thoracic deformities that result in inefficient coupling between the respiratory muscles and the thoracic cage. The disorders are usually characterised by a restrictive defect and share the potential of long term hypercapnic respiratory failure. Scoliosis and/or kyphoscoliosis may cause severe respiratory failure. Symptoms of respiratory failure include: dyspnoea on exertion, peripheral oedema, orthopnoea, repeated chest infections, morning headaches, fatigue, poor sleep quality and loss of appetite.

Otherwise healthy individuals may take advantage of systems and devices to prevent respiratory disorders from arising.

2.2.1 Systems

One known product used for treating sleep disordered breathing is the S9 Sleep Therapy System, manufactured by ResMed.

2.2.2 Therapy

Nasal Continuous Positive Airway Pressure (CPAP) therapy has been used to treat Obstructive Sleep Apnea (OSA). The hypothesis is that continuous positive airway pressure acts as a pneumatic splint and may prevent upper airway occlusion by pushing the soft palate and tongue forward and away from the posterior oropharyngeal wall.

Non-invasive ventilation (NIV) has been used to treat OHS, COPD, MD and Chest Wall disorders.

2.2.3 Patient Interface

The application of a supply of air at positive pressure to the entrance of the airways of a patient is facilitated by the use of a patient interface, such as a nasal mask, full-face mask or nasal pillows. A range of patient interface devices are known, however a number of them suffer from being one or more of obtrusive, aesthetically undesirable, poorly fitting, difficult to use and uncomfortable especially when worn for long periods of time or when a patient is unfamiliar with a system. Masks designed solely for aviators, as part of personal protection equipment or for the administration of anaesthetics may be tolerable for their original application,

but nevertheless be undesirably uncomfortable to be worn for extended periods, for example, while sleeping.

2.2.4 PAP Device

PAP devices are used to deliver positive airway pressure in many forms. For example, a positive pressure level may be maintained across the inspiratory and expiratory levels of the patient's breathing cycle at an approximately constant level. Alternatively, pressure levels may be adjusted to change synchronously with the patient's breathing cycle. For example, pressure may be set at one level during inspiration and another lower level during expiration for patient comfort. Such a pressure treatment system may be referred to as bi-level. Alternatively, the pressure levels may be continuously adjusted to smoothly replicate changes in the patient's breathing cycle. A lower pressure setting during expiration may generally be referred to as expiratory pressure relief.

In providing such changes to pressure and/or detecting conditions for making adjustments to the treatment pressure, it can be helpful to have a measure or estimation of patient respiratory flow or total volumetric flow. For example, a flow signal may be utilized to detect when a patient changes from inspiration to expiration for determining when to deliver expiratory pressure treatment settings or inspiratory pressure treatment settings. Similarly, the flow signal may be utilized to detect patient flow limitation for purposes of making treatment pressure adjustments. Such adjustments are illustrated in the U.S. Pat. No. 5,704,345. For these purposes, a measured flow signal may be derived from a flow sensor such as a differential pressure transducer or pneumotachograph. Alternatively, the flow signal may be estimated in the absence of a flow sensor.

2.2.5 Humidifier

Respiratory apparatuses commonly have the ability to alter the humidity of the breathable gas in order to reduce drying of the patient's airway and consequent patient discomfort and associated complications. The use of a humidifier placed between the flow generator and the patient interface produces humidified gas that minimizes drying of the nasal mucosa and increases patient airway comfort. In addition in cooler climates, warm air applied generally to the face area in and about the patient interface is more comfortable than cold air.

Many humidifier types are available, although the most convenient form is one that is either integrated with or configured to be coupled to the relevant respiratory apparatus. While passive humidifiers can provide some relief, generally a heated humidifier is required to provide sufficient humidity and temperature to the air so that the patient will be comfortable. Humidifiers typically comprise a water reservoir or tub having a capacity of several hundred milliliters (ml), a heating element for heating the water in the reservoir, a control to enable the level of humidification to be varied, a gas inlet to receive gas from the flow generator, and a gas outlet adapted to be connected to a patient conduit that delivers the humidified gas to the patient's mask.

Typically, the heating element is incorporated in a heater plate which sits under, and is in thermal contact with, the water tub. Thus, heat is transferred from the heater plate to the water reservoir primarily by conduction.

In the prior art, additional components have been used to improve thermal contact between the water reservoir and the heater plate. One example is the use of spring elements, which are used to connect the heater plate to the humidifier body, as described in U.S. Pat. No. 4,203,027, thereby pushing the heater plate towards the water reservoir. Another example is a humidifier with a lid wherein a compressible

elastomer seal is provided on the lid, as described in WO2010/031126. In this example, when the lid is in its closed position the seal engages against the water reservoir and pushes it against the heater plate.

Another aspect of a prior art humidifier water reservoir is that over-filling and/or tilting of the water reservoir may result in the flow of water back into the PAP device. The introduction of elongated inlets such as those disclosed in WO 2004/026382 has reduced the risk of spillage due to tilt, however the water reservoir still can be over-filled, and when this occurs it may reduce the effectiveness of such spill-protection system. As a result, such prior art humidifier water reservoirs have included a water filling indication mark to reduce occurrence of such over-filling.

3 BRIEF SUMMARY OF THE INVENTION

The present technology is directed towards providing medical devices used in the diagnosis, amelioration, treatment, or prevention of respiratory disorders having one or more of improved comfort, cost, efficacy, ease of use and manufacturability.

A first aspect of the present technology relates to apparatus used in the diagnosis, amelioration, treatment or prevention of a respiratory disorder.

Another aspect of the present technology relates to methods used in the diagnosis, amelioration, treatment or prevention of a respiratory disorder.

One form of the present technology comprises a humidifier reservoir or tub comprising an internal variable portion, which generates a force pushing the humidifier reservoir towards the heater plate when the humidifier reservoir is engaged with the humidifier. The variable portion may also include a seal.

Another aspect of one form of the present technology is a humidifier reservoir comprising a variable element which is compressed and generates a force pushing the humidifier reservoir towards the heater plate when the humidifier reservoir is engaged with the humidifier.

One form of the present technology comprises a humidifier reservoir wherein when the humidifier reservoir is engaged with the humidifier, the introduction of therapy pressure improves thermal engagement of the humidifier reservoir with the heater plate.

Another aspect of one form of the present technology is a humidifier reservoir comprising a means of using therapy pressure that is introduced within the humidifier reservoir to generate a force between the humidifier reservoir and the heater plate to improve thermal coupling between the humidifier reservoir and the heater plate.

One form of the present technology comprises a humidifier reservoir comprising an over-filling protection element configured to indicate over-filling.

In one form of the present technology the over-filling protection element may include at least one orifice in a wall of the reservoir. The at least one orifice defines an egress path of water when the predetermined maximum volume of water is exceeded.

In another form of the present technology the over-filling protection element may include a sloped profile in the side profile of a wall of the reservoir that defines an egress path of water when the predetermined maximum volume of water is exceeded.

Another aspect of one form of the present technology is a humidifier reservoir comprising an over-filling protection element to prevent the humidifier reservoir from filling beyond a predetermined or maximum capacity.

One form of the present technology comprises a humidifier reservoir comprising an inlet and outlet arranged to prevent spillage of water from the reservoir back through the inlet and/or outlet.

Of course, portions of the aspects may form sub-aspects of the present invention. Also, various ones of the sub-aspects and/or aspects may be combined in various manners and also constitute additional aspects or sub-aspects of the present invention.

Other features of the technology will be apparent from consideration of the information contained in the following detailed description, abstract, drawings and claims.

4 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The present technology is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to similar elements including:

4.1 Treatment Systems

FIG. 1a shows a system in accordance with the present technology. A patient 1000 wearing a patient interface 3000, receives a supply of air at positive pressure from a positive airway pressure (PAP) device 4000. Air from the PAP device is humidified in a humidifier 5000, and passes along an air circuit 4170 to the patient 1000.

FIG. 1b shows a PAP device in use on a patient with a nasal mask.

FIG. 1c shows a PAP device in use on a patient with a full-face mask.

4.2 Therapy

4.2.1 Respiratory System

FIG. 2a shows an overview of a human respiratory system including the nasal and oral cavities, the larynx, vocal folds, oesophagus, trachea, bronchus, lung, alveolar sacs, heart and diaphragm.

FIG. 2b shows a view of a human upper airway including the nasal cavity, nasal bone, lateral nasal cartilage, greater alar cartilage, nostril, lip superior, lip inferior, larynx, hard palate, soft palate, oropharynx, tongue, epiglottis, vocal folds, oesophagus and trachea.

4.3 Patient Interface

FIG. 3a shows a patient interface in accordance with one form of the present technology.

4.4 PAP Device

FIG. 4a shows a PAP device in accordance with one form of the present technology.

FIG. 4b shows a schematic diagram of the pneumatic components of a PAP device in accordance with one form of the present technology. The directions of upstream and downstream are indicated.

It should be understood that a number of components, such as supplementary O₂ 4180, anti-spill back valve 4160, or the transducer(s) 4270 are optional. Also, in an alternative arrangement the humidifier 5000 may be placed in alternative locations for example, upstream of the pneumatic block 4020.

4.5 Humidifier

FIG. 5a shows a simplified representation of a humidifier connected to a blower and a patient conduit

FIG. 5b shows a schematic of a humidifier.

4.6 Breathing Waveforms

FIG. 6a shows a model typical breath waveform of a person while sleeping, the horizontal axis is time, and the vertical axis is flow. While the parameter values may vary, a typical breath may have the following approximate values:

tidal volume, V_t, 0.5 L, inhalation time, T_i, 1.6 s, peak inspiratory flow, Q_{peak}, 0.4 L/s, exhalation time, T_e, 2.4 s, peak expiratory flow, Q_{peak}, -0.5 L/s. The total duration of the breath, T_{tot}, is about 4 s. The person typically breathes at a rate of about 15 breaths per minute (BPM), with Ventilation, Vent, about 7.5 L/s. A typical duty cycle, the ratio of T_i to T_{tot} is about 40%.

4.7 PAP Device with a Humidifier

FIG. 7 shows a prior art example of a PAP device 4000 and a humidifier 5000.

FIG. 8 shows an example of the present technology, showing a PAP device 4000 and an integrated humidifier 5000.

FIGS. 9-12 show various views of a humidifier reservoir 5110 in accordance with one aspect of present technology, wherein FIG. 9-10 show the humidifier reservoir 5110 in a 'closed' configuration, FIG. 11 shows the humidifier reservoir 5110 in an 'open' configuration, and FIG. 12 is an exploded view of the humidifier reservoir 5110.

FIGS. 13-16 show the humidifier 5000 from various perspectives, in particular demonstrating the engagement of the humidifier reservoir 5110 with the reservoir dock 5130.

FIGS. 17-19 show a time-lapse chart of an exemplary flow path of gas as it enters the humidifier reservoir 5110 through the inlet 5118 and exits through the outlet 5122 after traversing through the inside of the humidifier reservoir 5110.

FIGS. 20-21 show exemplary distributions of pressure/force in the humidifier reservoir 5110 in various configurations.

FIGS. 22-29 show varying configurations of the reservoir lid 5114, in particular variations in configurations of the inlet tube 5124 and the outlet tube 5126 according to aspects of the present technology.

FIGS. 30a and 30b show the humidifier reservoir 5110 and in particular they aim to show the orifice 5138 according to an example of the present technology.

FIGS. 30c and 30d show the humidifier base 5112 and in particular the sloped profile 5139 according to an example of the present technology.

FIG. 31 shows the humidifier reservoir 5110 and in particular the orifice 5138 according to an example of the present technology.

FIGS. 32-33 show the humidifier dock 5130 and the humidifier reservoir 5110, and in particular show the interaction between the lid protrusion 5142 and the dock locking recess 5144 according to one aspect of the present technology.

FIG. 34 show an example of the humidifier reservoir 5110 according to another example of the current technology, wherein it is configured with a re-filling cap 5180 and a base, top and variable portion may be affixed together.

FIGS. 35-38 shows other representations of a humidifier reservoir 5110 according to an aspect of the present technology, with particular regard to the arrangement of the inlet tube 5124 and the outlet tube 5126.

FIG. 39 shows a cross-sectional view of a reservoir lid 5114 and a variable portion in the form of a seal 5116 according to an aspect of the present technology.

FIG. 40 shows an example of the humidifier reservoir 5110 according to another example of the present technology, wherein it is configured with a latch 5186.

5 DETAILED DESCRIPTION OF THE INVENTION

Before the present technology is described in further detail, it is to be understood that the technology is not limited to the particular examples described herein, which may vary.

It is also to be understood that the terminology used in this disclosure is for the purpose of describing only the particular examples discussed herein, and is not intended to be limiting.

5.1 Treatment Systems

In one form, the present technology comprises apparatus for treating a respiratory disorder. Preferably the apparatus comprises a flow generator or blower for supplying pressurised respiratory gas, such as air, to the patient 1000 via an air delivery tube leading to a patient interface 3000.

5.2 Therapy

In one form, the present technology comprises a method for treating a respiratory disorder comprising the step of applying positive pressure to the entrance of the airways of a patient 1000.

5.2.1 Nasal CPAP for OSA

In one form, the present technology comprises a method of treating Obstructive Sleep Apnea in a patient by applying nasal continuous positive airway pressure to the patient.

5.3 Patient Interface 3000

A non-invasive patient interface 3000 in accordance with one aspect of the present technology comprises the following functional aspects a seal-forming structure 3100, a plenum chamber 3200, a positioning and stabilising structure 3300 and a connection port 3600 for connection to an air circuit 4170. In some forms a functional aspect may be provided by one or more physical components. In some forms, one physical component may provide one or more functional aspects. In use the seal-forming structure 3100 is arranged to surround an entrance to the airways of the patient so as to facilitate the supply of air at positive pressure to the airways.

5.4 PAP Device 4000

A preferred PAP device 4000 in accordance with one aspect of the present technology comprises mechanical and pneumatic components 4100, electrical components 4200 and is programmed to execute one or more algorithms 4300. FIG. 7 shows a prior art embodiment of a PAP device 4000, which is connectable to a humidifier 5000. The PAP device may also be integrated with a humidifier 5000 so that an external housing 4010 encases the components that perform the equivalent function of a PAP device 4000 as well as components that perform the equivalent function of a humidifier 5000.

FIG. 8 shows an example embodiment of such an integrated device comprising a PAP device 4000 and a humidifier 5000. It should be understood that subsequent references to a humidifier 5000 refers to the integrated device, in particular the components that perform the equivalent function of a humidifier 5000.

5.5 Humidifier 5000

5.5.1 Humidifier Overview

In one form of the present technology there is provided a humidifier 5000 comprising a water reservoir 5110, a heater plate 5120 and a water reservoir dock 5130.

5.5.2 Humidifier Mechanical Components 5100

5.5.2.1 Water Reservoir Dock 5130

A water reservoir dock 5130 may be integrated with the humidifier 5000 as shown in FIG. 13-16. In this arrangement, the reservoir dock 5130 comprises a breathable gas outlet 5168 to output a flow of breathable gases to a water reservoir 5110, a humidified breathable gas inlet 5170 to receive the flow of breathable gases that has been humidified in the water reservoir 5110, and an air delivery conduit outlet 5172 to transfer the flow of humidified breathable gases to the air delivery conduit 4170. As shown in FIG. 14, the water reservoir dock 5130 may form a cavity 5160 to receive the water reservoir 5110. The cavity 5160 may include a top portion configured to cover at least a portion of the lid of the reservoir 5110 and a bottom portion including the heater plate 5020.

It should be understood that the reservoir dock 5130 may be provided separately to a humidifier 5000 in an alternate arrangement. In such an arrangement, additional interfaces may be used to connect the reservoir dock 5130 to the humidifier 5000.

In another arrangement, a water reservoir dock 5130 may comprise an opening in a substantially horizontal plane, so that the water reservoir 5110 may be inserted from above or below the water reservoir dock 5130.

5.5.2.2 Water Reservoir 5110

FIG. 9-12 show an example of a water reservoir 5110 according to the technology, which comprises a reservoir base 5112, a reservoir lid 5114, and a variable portion 5116. As shown in this example arrangement the variable portion 5116 may also function as a seal between the base 5112 and the reservoir lid 5114. The reservoir forms a cavity formed by a plurality of walls to hold a volume of liquid or water. The cavity of the reservoir 5110 is configured so that it is able to hold a given, maximum volume of liquid or water, typically several hundred milliliters, for example 300 milliliters (ml), 325 ml, 350 ml or 400 ml, although it is to be understood that other volumes of liquid may be utilised such as 100 ml, 200 ml, 250 ml, 500 ml or more or less.

The lid 5114 may comprise an inlet 5118 and an outlet 5122. The inlet 5118 comprises an inlet tube 5124 and the outlet 5122 comprises an outlet tube 5126. The lid 5114 may be pivotably connected to the base 5112 by hinges 5158 in such a way that it is able to be moved between an open position, as shown in FIG. 11, and a closed position, as shown in FIG. 9 and FIG. 10. When the water reservoir 5110 is in its closed configuration, the variable portion 5116 is put into sealing engagement between the base 5112 and the lid 5114.

The variable portion 5116 may be provided as part of the reservoir lid 5114 or as part of the reservoir base 5112, or independently of both. The variable portion 5116 may be engaged with the reservoir lid 5114 or the reservoir base 5112 by any number of means including, and not limited to, ultrasonic welding, friction fitting, gluing or by using an intermediate component. The variable portion 5116 may comprise a carrier 5117 (as shown in FIG. 12).

In an arrangement, the variable portion 5116 may not be directly engaged with the base 5112 or lid 5114 but coupled to one or both of the lid 5114 and the base 5112 such that each of the base 5112 and the lid 5114 may be formed as two separate parts that are able to be assembled with the variable portion 5116 coupled therebetween. Alternatively the variable portion 5116 may be coupled to either the lid 5114 or the base 5112.

In an alternative arrangement the variable portion 5116 may be located within a wall of the reservoir base 5112.

and/or a wall of the reservoir lid **5114** rather than being on the edge of either the reservoir base **5112** or the reservoir lid **5114**. Thus, in such an arrangement the variable portion would not be between the reservoir base **5112** and the reservoir lid **5114** but within the reservoir base **5112** and/or the reservoir lid **5114**. There may be more than one variable portion **5116** to provide more compliance in movement of the reservoir **5110**.

The reservoir base **5112** comprises a conducting portion that is configured to couple with a heater plate **5130** of the humidifier to allow thermal engagement and thermal transfer of heat to the liquid or water within the base. The base may comprise a base upper body **5146**, a base bottom plate **5148**, and a conducting portion in the form of a base conductor plate **5152**, as shown in FIG. 12. All or a part of the base conductor plate **5152** may be made of a different material (e.g. aluminium or another heat conducting metal) than the base upper body **5146** and/or the base bottom plate **5148**, which may be made of a plastic or thermoplastic polymer, for example, a polycarbonate material. The base conductor plate **5152** may comprise of a sealing element **5150**, which may be integrated to, and/or sealingly connected to both the base upper body **5146** and the base bottom plate **5148** to prevent egress of water from the water reservoir **5110** through its bottom.

It should be appreciated that the reservoir base **5112** may be constructed in any number of parts. The reservoir base **5112** may be constructed as a single part made of, for example, aluminium or another heat conducting metal. In another arrangement, the reservoir base **5112** may be constructed in multiple parts such as two parts comprising a lower component and an upper component. The lower component may include: a reservoir base conductor plate **5152**, sealing element **5150** and base bottom plate **5148**. The base bottom plate is constructed at least in part from a heat conducting material, for example, aluminium or another heat conducting metal. The upper component may include a base upper body **5146** constructed from, for example, a polycarbonate material. The upper and lower components may be sub-divided to form further arrangements consisting of greater number of parts, for example the sealing element **5150** may be a separate component.

Water Reservoir-to-Humidifier Connection

When in use, the water reservoir **5110** is removably coupled with the humidifier **5000** as shown in FIG. 13-16 by inserting the water reservoir into the water reservoir dock **5130**, for example by sliding, so that the inlet **5118** of the water reservoir **5110** is configured to receive the flow of breathable air that is output by the PAP device **4000**, and to direct the flow of breathable air into the water reservoir **5110**. Moisture is added to the flow of breathable air as the breathable air travels through the reservoir **5110**, and the humidified flow of breathable air exits the reservoir **5110** through the outlet tube **5126** and to the reservoir outlet **5122**. The reservoir outlet **5122** is connectable to an air delivery circuit or air delivery conduit **4170** to deliver the flow of humidified breathable air to the patient **1000**.

The double-ended arrows in FIG. 14 and FIG. 16 show the direction of relative motion, i.e. generally horizontal movement, between the humidifier **5000** and the water reservoir **5110** in connecting and disconnection with each other in this arrangement. However, it is noted that the water reservoir **5110** may be coupled to the humidifier **5000** by other means such as being inserted into the humidifier in a generally vertical direction. In the illustrated arrangement the reservoir outlet **5122** is connected to the reservoir dock outlet **5168**, through which the humidified flow of breathable air

travels to the humidifier outlet **5172**. The humidifier outlet **5172** is connectable to the air delivery circuit or air delivery conduit **4170** as indicated in FIG. 13 by the double-ended arrow. One feature of such an arrangement is that the humidifier reservoir **5110** must be removed from the reservoir dock **5130** to fill the humidifier reservoir **5110** with water. This arrangement may reduce the likelihood of the user over-filling the water reservoir **5110** over the given, maximum volume of liquid or water, as the humidifier reservoir **5110** incorporates means to prevent over-filling when the lid **5114** is in its open position as described further below.

As shown in FIG. 16, first and second dock seals **5132**, **5134** may be provided to seal the connection between the reservoir inlet **5118** and the dock **5130** and the connection between the reservoir outlet **5122** and the dock **5130**.

Reservoir Handles

FIG. 13-16 show an upper handle **5154** that is located on the reservoir lid **5114**, and a lower handle **5156** that is located on the reservoir base **5112**. These handles are intended to assist the patient **1000** to grip and hold the water reservoir **5110**. In the shown arrangement, the handles **5154** **5156** are located away from the hinges **5158** such that by holding the reservoir **5110** by the handles **5154** **5156** the patient **1000** imparts forces onto the reservoir **5110** compressing the variable portion **5116**, which pushes the lid **5114** and the base **5112** towards each other. This compression force may also help maintain the variable portion **5116** in sealing engagement between the reservoir base **5112** and the reservoir lid **5114**. It is to be understood that the handles **5154** and **5156** may be placed on other components or areas of the water reservoir **5110**. A friction grip **5166** may be provided on a surface of either or both of the handles **5154** **5156** as shown in FIG. 14. The friction grip **5166** may be constructed from a higher friction material than the primary material used to construct the water reservoir **5110**. For example, the friction grip **5166** may be constructed from an elastomeric material such as silicone whereas the water reservoir **5110** may primarily be constructed from a polycarbonate material.

Reservoir Variable Portion

In the illustrated arrangement, when the water reservoir **5110** is in use, the variable portion **5116** is maintained in sealing engagement between the reservoir base **5112** and the reservoir lid **5114**. However, as mentioned above the variable portion **5116** may alternatively be formed as part of the reservoir base **5112** and/or the reservoir lid **5114** and not form a seal between the reservoir base **5112** and the reservoir lid **5114**. The variable portion **5116** may be constructed from an elastomeric material such as silicone, TPE, TPE polyester, TPE polyurethane or natural rubber. In choosing the material to be used for the variable portion **5116** it may be advantageous to choose one that does not experience mechanical relaxation across the range of storage and operational temperatures that the variable portion **5116** may be exposed to. One example of a material for the variable portion **5116** which meets these requirements may be silicone.

In the arrangement shown in FIG. 15-16, the water reservoir **5110** is connected with the humidifier **5000** by placing the water reservoir **5110** in the water reservoir dock **5130**. In this arrangement, the heights and shapes of the dock internal cavity **5160** and the water reservoir **5110** are such that when the water reservoir **5110** is engaged with the water reservoir dock **5130** the variable portion **5116** is compressed, for example by between about 1 mm and about 5 mm, for example by about 2 mm, about 3 mm or about 4

mm. Thus, the shape of the portion of the water reservoir **5110** that is inserted into the dock **5130** is complementary to the shape of the dock cavity **5160** and the height of the water reservoir **5110** when variable portion **5116** is compressed is slightly less than the height of the dock cavity **5160** to enable the insertion of the water reservoir **5110** into the dock cavity **5160**. The variable portion **5116** may be constructed with a cross-section shape such as one shown in FIG. **39**. A compressive force is required to sufficiently compress the variable portion to allow relative movement, such as sliding between the water reservoir **5110** and the water reservoir dock **5130**. For example a compression force as measured at the handle recesses **5154**, **5156** of between about 10 N and about 30 N, or about 20 N, or some other compression force as required to allow insertion of the water reservoir **5110** into the dock cavity **5160**. The vertical gap achieved between the water reservoir **5110** and the dock internal cavity **5160** may be between about 1 mm and about 5 mm, for example about 2 mm, 3 mm or 4 mm, when the compressive force is applied at the handle recesses and the water reservoir **5110** is connected with the reservoir dock **5130**. The water reservoir **5110** and the reservoir dock **5130** may be arranged so that the amount of compression in the variable portion **5116** is reduced once the water reservoir **5110** is connected with the reservoir dock **5130** and the patient **1000** is no longer applying a compressive force. The reduction in compression may be between about 0.5 mm and about 2.5 mm, for example about 1 mm, 1.5 mm or 2 mm.

A reservoir latch **5186** may be provided on the water reservoir **5110**, as shown in FIG. **39**, so that when the reservoir latch **5186** is engaged, it secures the reservoir lid **5114** and reservoir base **5112** together to prevent the reservoir lid **5114** and the reservoir base **5112** from separating and maintains the variable portion **5116** in a compressed state. The latch may also maintain the variable portion **5116** in sealing engagement between the lid **5114** and the base **5112** when the variable portion **5116** is located between the lid **5114** and the base **5112**. The latch **5186** may be configured to allow further compression of the variable portion **5116**. This would allow insertion of the water reservoir **5110** into the reservoir dock **5130** in the manner described above, and for the variable portion **5116** to retain its advantageous properties regarding improvements to thermal engagement as described below.

In an alternative arrangement, not shown, the water reservoir **5110**, may be inserted into the dock cavity **5160** from a vertical direction rather than using a sliding motion. In such an arrangement the dock cavity of the humidifier **5000** may comprise a moveable cover portion, such as a lid or top portion, that is at least partially opened to allow insertion of the water reservoir **5110** and closed following insertion to secure the water reservoir **5110** within the dock cavity **5160**.

Air Flow Path

FIG. **17-19** show an exemplary path of the flow of breathable air through the reservoir **5110** as it enters through the inlet **5118** and exits through the outlet **5122**. The figures are arranged chronologically in three distinct orthogonal views per figure to demonstrate the exemplary flow path visually. In this arrangement the flow of breathable air received through the inlet **5118** passes through the inlet tube **5124** (FIG. **17**), into the internal volume of the water reservoir **5110** (FIG. **18**), and then passes through the outlet tube **5126** to exit the water reservoir **5110** at the outlet **5122** (FIG. **19**) as humidified breathable air. FIG. **17-19** show the reservoir **5110** with the lid **5114** and the base **5112** in exploded view orientation for clarity, and any flow of the air

that occurs in the internal volume of the reservoir **5110** is shown in dotted lines, and the direction of the arrows shown indicate the general direction of the exemplary flow of breathable air. Although it is noted that the nature of gas or air flow may involve the swirling of air rather than a straight and direct air flow path.

The path of the flow of breathable air demonstrated in FIG. **17-19** is exemplary only, and is aimed to demonstrate one of many paths that the flow of breathable air may traverse through, namely that it enters the water reservoir **5110** through the inlet **5118** and exits through the outlet **5122** after experiencing some degree of swirling within the volume of the water reservoir **5110**. A person skilled in the art would understand that the particles or molecules that form the flow of breathable air may not follow a single path within the water reservoir **5110** due to a number of factors, including, for example, localised turbulence (eddies) or pressure gradients within the water reservoir **5110**. As a result the cumulative path of the flow of breathable air may comprise any number of paths wherein it experiences various degrees of 'swirling' within the water reservoir **5110** prior to exiting via the outlet tube **5126** at the outlet **5122**. It is also possible that some small portion of the flow of breathable air may escape the water reservoir **5110** as a leak.

Thermal Contact/Engagement

One aspect of this technology is improved thermal contact or engagement between the base **5112** of the water reservoir and the heater plate **5120** of the humidifier. The improved thermal contact or engagement may be facilitated by the supply of pressurized gas to the humidifier reservoir **5110** from a PAP device.

In one arrangement, the water reservoir **5110** may be configured so that when it is placed in the water reservoir dock **5130** the reaction to the compression of the variable portion **5116**, i.e. a force attempting to expand the variable portion **5116**, pushes the base **5112** of the water reservoir **5110** against the heater plate **5120** to improve the level of thermal engagement between the heater plate **5120** and the base **5112**. This occurs as a result of the variable portion **5116** initially being compressed when it is inserted into the reservoir dock **5130** as described above, and then the compression is released or reduced allowing the variable portion **5116** to expand towards its relaxed or uncompressed state. Thus, the variable portion **5116** is acting like a spring that may be biased to push the reservoir base **5112** and/or the reservoir lid **5114** in a direction perpendicular to the heater plate **5120** until the variable portion **5116** is in a reduced compressed state. As the reservoir **5110** is confined within the reservoir dock **5130** or by some other means the level of compression of the variable portion **5116** is transferred as a force that encourages improved thermal engagement with the heater plate **5020**. FIG. **20** illustrates this effect by indicating the distributed forces or pressures that are applied to the lid **5114**, variable portion **5116** and the base **5112** by the arrows shown.

The force required for compression of the variable portion **5116** when the water reservoir **5110** is connected with the humidifier **5000** is primarily in the direction tangential to the pivoted opening direction of the water reservoir **5110**, which may be the same direction as the normal to a surface of the conductive portion, and is reacted by the water reservoir dock **5130** at its contacting points and/or surfaces, thereby pushing the base **5112** of the water reservoir **5110** and the heater plate **5120** together. As a corollary, a decrease of the compression resulting in an increase in height of the variable portion **5116** will reduce the force between the base **5112** and the heater plate **5120**. In other words, varying the height

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of the variable portion in the reservoir varies a level of thermal engagement between the conductive portion and the heater plate.

The water reservoir **5110** may be configured so that the direction of thermal engagement with the heater plate **5120** is in the same direction as the normal direction of a surface of the conductive portion.

The magnitude of this force may be between about 5 N and about 15 N when measured at the heater plate **5120** when the water reservoir **5110** is placed in the water reservoir dock **5130**. However, it should be understood that different configurations of the water reservoir **5110** may require different magnitudes of compression force. The magnitude of this force may be altered by modifying the design of any or all of the seal **5116**, the lid **5114**, the base **5112**, or the reservoir dock **5130**. For instance if the variable portion **5116** was constructed of a material with higher Young's modulus, it would correspondingly increase the magnitude of the force. It should be noted that FIG. **20** only shows forces and pressures in the vertical direction.

Furthermore, when the water reservoir **5110** is connected with the humidifier **5000**, the pressurized flow of breathable air received from the PAP device pressurizes the interior of the reservoir **5110** and may further encourage an expansion of the variable portion **5116** that pushes the base **5112** of the water reservoir **5110** against the heater plate **5120** to improve the level of thermal engagement, or the level of thermal contact, between the heater plate **5120** and the base **5112**. FIG. **21** illustrates this effect by indicating the distributed forces or pressures that are applied to the lid **5114** and the base **5112** by the arrows shown. The presence of above-atmospheric pressure within the water reservoir **5110** is shown to result in forces in the direction of thermal engagement, and is reacted by the water reservoir dock **5130** at its contacting surfaces, thereby pushing the base **5112** of the water reservoir **5110** and the heater plate **5120** towards each other in the direction of thermal engagement. The magnitude of this force may be between about 5 N and about 15 N when measured at the heater plate **5120** at 20 cm H₂O of pressure. However, it should be understood that different configurations of the water reservoir **5110** may require different magnitudes of force, which may be achieved by varying the surface area that the pressure acts on, or the effective pressure that acts on the surface. Such changes may be achieved, for example, by a pressure regulating valve. It should be noted that FIG. **21** only shows forces and pressures in the vertical direction, as the thermal engagement occurs in the vertical direction. Thus, the variable portion in the reservoir **5110** enables movement of the reservoir base **5112** and/or the reservoir lid **5114** in response to an increase in pressure above atmospheric pressure in the reservoir **5110** to improve thermal engagement of the reservoir base **5112** with the heater plate **5020**. It is envisaged that, in another arrangement, substantially the same effects as those described above may be achieved with a non-opening variable portion of a water reservoir **5110**. The water reservoir **5110** and the reservoir dock **5130** may be substantially arranged so that elasticity or flexibility is provided by an elastomeric material or a joint that allows freedom of movement (e.g. a sliding connection, or a concertina section of pliable plastic or a flexible portion in the water reservoir) in the direction of the heat transfer. In this configuration the lid **5114** and the base **5112** may be unconstrained relative to each other in the direction of thermal contact. The reservoir **5110** may then be constrained in the direction of the heat transfer in another manner (e.g. by a water reservoir dock or a similar housing) to create a force that reacts to balance the

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pressure created in the interior of the reservoir **5110** by the pressurized flow of breathable air, wherein some of the reaction force may occur at the heater plate **5120** to improve thermal contact. In such arrangements, another opening to re-fill the water reservoir **5110** may be introduced on the reservoir **5110**, such as on the lid **5114**, and it may comprise a separate seal. Such an opening may be configurable between an open and a closed position, for example, by a cap or a refilling lid. FIG. **34** shows an example of such an arrangement, including a base **5174**, a top **5176**, a variable portion **5178** and a re-filling cap **5180**. The base, the top and the variable portion may be affixed together in this arrangement, and in such a case re-filling of the reservoir would be accommodated by the re-filling cap, **5180**. The re-filling cap **5180** may be placed such that when the humidifier reservoir **5110** is engaged with the reservoir dock **5130** the re-filling cap **5180** is not accessible. Such an arrangement may preserve the advantage described above, namely that the reservoir **5110** is not able to be re-filled while it is engaged with the reservoir dock **5130**. Furthermore, the variable portion **5178** may be replaced by any mechanism known in the art that is able to accommodate a change in vertical length within a reservoir.

In a yet another alternate arrangement, the pressurized flow of breathable air may be used to improve the level of thermal contact between the humidifier reservoir **5110** and the heater plate **5120** by pressurisation or inflation of a chamber, body or surface that acts on the humidifier reservoir **5110**, which in turn may push the water reservoir **5110** and the heater plate **5120** together in the direction of thermal engagement. Similarly the supply of the pressurized flow of breathable air may pressurize or inflate a chamber, body or surface that acts upon the heater plate to push the heater plate **5120** and water reservoir **5110** together in the direction of thermal engagement.

The chamber may be arranged on the outside of the reservoir and communicated with the flow of breathable gas. A surface of the chamber may be connected with the reservoir in the direction of thermal engagement so that varying the pressure of the flow of breathable gas in the reservoir varies the size of the chamber and changes a level of thermal engagement between the conductive portion and the heater plate. The chamber being arranged to push the reservoir towards the heater plate **5020** and/or the heater plate **5020** towards the reservoir when the size of the chamber increases.

In an alternate arrangement of the reservoir dock **5160**, wherein the opening is substantially in the horizontal plane and thus the water reservoir **5110** is inserted from above or below the reservoir dock **5160** as described above, the water reservoir dock **5160** may include a retaining mechanism (for example, a lid that closes above the water reservoir **5110**) to hold the water reservoir **5110** in its intended position. In such an arrangement, the reservoir dock lid may be configured to compress the variable portion **5116** which would in turn push the reservoir **5110** against the heater plate **5120**. Similarly, the reservoir **5110** may be configured so that when the reservoir dock lid is closed, and the pressurized flow of breathable air pressurizes the interior of the reservoir **5110**, it pushes the reservoir lid **5114** and the reservoir base **5112** apart that acts on the variable portion to try to expand or un-compress the variable portion, and in turn enhances the level of thermal contact between the reservoir base **5112** and the heater plate **5120**.

The level of thermal contact may also be improved using a spring loaded or sprung heater plate as is known in the prior art. The heater plate may be constructed with a convex

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or domed shape towards the humidifier reservoir **5110** so that when the humidifier **5110** is engaged with the reservoir dock **5130** the convex heater plate is flattened, which generates a clamping force pushing the heater plate **5120** to the water reservoir **5110**. Similarly, the conductor plate **5152** of the water reservoir **5110** may be domed or convex shaped and be configured to be flattened towards the heater plate when the water reservoir **5110** is engaged. in the dock cavity **5180** of the humidifier **5000**.

Any one of the above means of improving thermal contact may be used independently of each other, or in any combination thereof, including in combination with any prior art means of achieving or improving thermal engagement between the humidifier reservoir and the heater plate.

Reservoir Inlet/Outlet

In one arrangement, the reservoir inlet **5118** and the reservoir outlet **5122** may be oriented horizontally and on the same surface, as shown in FIG. **12**. The reservoir inlet **5118** includes an inlet tube **5124** that extends from the exterior of the reservoir into the interior volume of the reservoir to provide a flow path for the inlet flow of pressurized gas into the reservoir **5110**. The reservoir outlet **5122** includes an outlet tube **5126** that extends from the interior of the reservoir **5110** to the exterior of reservoir **5110** to provide a flow path for the outlet flow of humidified pressurized gas from the reservoir **5110**, as shown in FIG. **22**.

As shown in FIG. **22-23**, the reservoir **5110** may include an end wall **5128** that is near and opposed to an interior end **5125** of the inlet tube **5124**. The inlet tube **5124** directs the inlet airflow to the inner end wall **5128** of the reservoir **5110** thus directing the air to flow across the whole water surface before it reaches an interior end **5127** of the outlet tube **5126** and flows out of the outlet **5122** through the outlet tube **5126**. FIG. **24-27** show examples of other arrangements, wherein the reservoir **5110** may include a turning vane **5136** which is placed near the interior end **5125** of the inlet tube **5124**. The turning vane **5136** may be formed as an extension of the inlet tube **5124** as shown in FIG. **26-27**, or the turning vane **5136** may be a separate component located adjacent to or coupled with the inlet tube **5124**. The turning vane may also be profiled as shown in FIG. **26-27**.

The water reservoir **5110** is preferably configured to provide tilt spillback protection from the water flowing back through the outlet tube **5126** or the inlet tube **5124**. Water egress through the inlet tube **5124** is particularly undesirable as it may introduce water into the PAP device **4000** and may damage electronic components (such as an electric motor, a flow sensor or a printed circuit board) from exposure to water. In one arrangement the reservoir **5110** achieves spillback protection by arranging the inlet tube outlet **5125** so that when the reservoir **5110** is rotated by 90 degrees in any direction from its working, horizontal orientation the given maximum volume of water is able to be stored in the reservoir **5110** without reaching the inlet tube outlet **5125**.

In another arrangement, the reservoir **5110**, the axes of inlet tube **5124** and the outlet tube **5126** may intersect when viewed from above as shown in FIG. **28-29**. The inlet tube **5124** and outlet tube **5126** are not connected to each other as one of the tubes passes below the other tube, such as the inlet tube **5124** passes below the outlet tube **5126**.

This configuration may improve the tilt spillback protection by arranging the inlet tube **5124** and the outlet tube **5126** such that when the reservoir **5110** is tilted to its side (substantially about the axis of the inlet/outlet), and water reaches the lower of the interior end **5125** of the inlet tube **5124** or the interior end **5127** of the outlet tube **5126**, the

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water must rise higher to exit the reservoir **5110** as shown in FIG. **29**. In comparison, if the inlet tube **5124** and the outlet tube **5126** were parallel, when water reaches the lower of the interior end **5125** of the inlet **5124** or the interior end **5127** of the outlet tube **5126** it would then be able to freely flow out of the reservoir **5110** through the inlet tube **5124** or the outlet tube **5126**.

One example of the above spillback prevention technology arranges the inlet tube **5124** and the outlet tube **5126** such that the axes defined by the interior end **5125** of the inlet **5124** and the exterior end **5190** of the outlet **5126** and the interior end **5127** of the outlet **5126** and the exterior end **5188** of the inlet **5124** are substantially parallel to each other.

Crossing the inlet tube **5124** and the outlet tube **5126** creates a geometric configuration wherein the water level must reach the higher of the inlet and outlet tube interior ends **5125**, **5127** to be able to exit the reservoir **5110**, or the water level must reach the lower of the inlet and outlet tube interior ends **5125**, **5127** and extend along the entire length of the inlet tube **5124** or outlet tube **5126** to be able to exit the reservoir **5110**.

Simplified representations of the effects created by crossed inlet and outlet tubing are shown in FIG. **35-38** (FIG. **35-36** shows one configuration, FIG. **37-38** another), wherein the internal surfaces are shown by dotted lines. These figures show alternate arrangements of a water reservoir **5110**, with an inlet **5118** and an outlet **5122** that respectively include an inlet tube **5124** and an outlet tube **5126** extending into a cavity or interior volume of the reservoir, and terminating at an interior end **5125** of the inlet tube **5124** and an interior end **5127** of the outlet tube **5126** respectively. FIG. **35-36** show a configuration wherein the axes of the tubing substantially intersect when viewed from the side (as shown in FIG. **36**), and FIG. **37-38** show an alternate configuration wherein the axes of the tubing are substantially parallel when viewed from the side (as shown in FIG. **38**). In FIG. **35-38**, a volume of water **5182** is assumed to fill approximately half of the volume of the reservoir **5110**, and is indicated by the dotted lines extending horizontally approximately at the mid-height of the reservoir **5110**.

When the water reservoir **5110** is oriented as shown in FIG. **35-36**, the arrangement of the inlet tube **5124** and the outlet tube **5126** requires the water level **5184** to rise above the entire length of the inlet tube **5124** to reach the exterior end of the inlet tube or to rise above the interior end **5127** of the outlet tube **5126** if any water **5182** is to exit the water reservoir **5110**. On the other hand, in the arrangement shown in FIG. **36-37** the water level **5184** only needs to rise as high as the lower of the inlet tube **5124** or the outlet tube **5126** in order to exit the water reservoir **5110**. As the water level **5184** will change as a function of the orientation of the water reservoir **5110**, this effect of crossing the inlet tube **5124** and the outlet tube **5126** may be re-created at any orientation as required by re-orienting the inlet tube **5124** and the outlet tube **5126** to suit the shape of the water reservoir **5110**.

The inlet tube may deliver a supply of breathable gas into the cavity of the reservoir and the outlet tube may deliver a humidified supply of breathable gas from the cavity. The inlet interior end and the outlet interior end are located within the cavity and the inlet exterior end and the outlet exterior end are located in one of the plurality of walls of the cavity. A first axis is defined by the inlet interior end and the inlet exterior end and a second axis is defined by the outlet interior end and the outlet exterior end. When the reservoir is tilted approximately 90° to normal working orientation the first axis is on a first angle such that the inlet interior end and

the inlet exterior end are positioned at different heights, such that the predetermined maximum volume of water is below at least one of the inlet interior end or the inlet exterior end to prevent spillback of water through the inlet tube. Furthermore, when the reservoir is tilted approximately 90° to normal working orientation the second axis is on a second angle such that the outlet interior end and the outlet exterior end are positioned at different heights, such that the predetermined maximum volume of water is below at least one of the outlet interior end or the outlet exterior end to prevent spillback of water through the outlet tube.

Overfill Prevention

Another aspect of this technology is the inclusion of an overfill protection element configured to prevent filling the reservoir above the maximum volume of water when filling the humidifier reservoir in its open configuration. In one arrangement as seen in FIGS. 30a and 30b, the overfill protection element may include at least one orifice 5138 in the water reservoir 5110 to indicate over-filling. According to this aspect of the technology, when the water reservoir 5110 is being re-filled with the reservoir lid 5114 open, over-filling beyond a predetermined level or the maximum capacity or volume for the reservoir 5110 would cause water to spill out from the orifice 5138. The water spilling out through orifice 5138 indicating that a maximum capacity has been reached and preventing the water reservoir 5110 from being filled beyond a predetermined level or maximum capacity. Advantageously water would spill out only through the at least one orifice 5138 rather than from all areas of the water reservoir resulting in less overflow spillage for the user to clean up. Thus, the at least one orifice defines an egress path of water when the predetermined maximum volume of water is exceeded. FIG. 30a show the water reservoir 5110 in its open configuration, wherein an upper flange of the base 5112 does not span the perimeter of the entire opening, creating an orifice 5138. FIG. 30b shows a zoomed in section of the base 5112 indicating the at least one orifice 5138. The at least one orifice 5138 may be in the form of one or more apertures, holes, slits or slots, or any other form that allows communication of fluid into and out of the water reservoir 5110. The at least one orifice 5138 may be formed in one or more positions around the upper flange of the base 5112.

In an alternate arrangement, the overfill protection element may include a sloped profile 5139. As shown in FIGS. 30c and 30d, the reservoir base 5112 may be arranged so that its side profile has a sloped profile 5139 in one or more directions. This arrangement may also indicate over-filling when the reservoir base 5112 is re-filled with liquid or water. In this arrangement, when the reservoir lid 5114 is in its open configuration, water may spill out at the base of the sloped profile 5139 rather than from all areas of the reservoir. Thus, the sloped profile defines an egress path of water when the predetermined maximum volume of water is exceeded. Advantages of the above methods may be that over-filling may become more difficult than has been in the prior art, and presents another advantage that in response to attempted over-filling, spillage may occur at more predictable locations.

Another aspect of this technology is that when the water reservoir 5110 is in its closed position, a seal 5192 sealingly engages the base 5112 and the reservoir lid 5114 and blocks or seals the orifice 5138 or sloped profile 5139 preventing fluid communication into and out of the water reservoir 5110. One arrangement of this feature is shown in FIG. 31, which shows that when the reservoir lid 5114 is closed (lid not shown in this image), the seal 5192 sealingly engages

with the base 5112 on the outside of the orifice 5138 and no longer allows communication of liquid or air into and out of the water reservoir 5110 through the orifice 5138. Similarly the seal 5192 would engage with the base 5112 to surround the edges of the sloped profile preventing communication of liquid or air into and out of the water reservoir 5110 through the sloped profile 5139. In some arrangements the seal 5192 may be integrated with the variable portion 5116 as described above. Alternatively the seal 5192 may be a separate seal that may be used in a reservoir with or without a variable portion.

Retaining Clip

The reservoir lid 5114 may include a means by which the water reservoir 5110 is to be retained in the water reservoir dock 5130 once the two members are engaged with each other. In one arrangement a retaining means may be a protrusion, or a clip, 5142 on the reservoir lid 5114 as shown in FIGS. 32-33. FIGS. 32-33 show a water reservoir 5110 and the reservoir dock 5130. Here, a protrusion, or a clip, 5142 on the reservoir lid 5114 removably engages with a corresponding dock locking recess 5144 in the water reservoir dock 5130 when the water reservoir 5110 is inserted into the water reservoir dock 5130. This connection secures the water reservoir 5110 relative to the water reservoir dock 5130. As described above the variable portion 5116 of the reservoir is compressed to enable insertion of the reservoir into the dock 5130. The compression of the variable portion 5116 allows a portion of the reservoir 5110 to slide into the dock 5130 and allows the protrusion or clip 5142 to slide initially under the outer edge surface of the dock 5130 to reach the dock locking recess 5144. The compression force applied to the reservoir for insertion may then be released to allow the protrusion or clip 5142 to engage with the dock locking recess 5144 and securing of the reservoir 5110 within the dock 5130. When the reservoir 5110 is secured within the dock 5130 the variable portion 5116 is no longer in or in a reduced compressed state. Similarly, in order to be able to remove the water reservoir 5110 from the water reservoir dock 5130, the variable portion 5116 must be compressed as to disengage the lid protrusion 5142 from the dock locking recess 5144. It would be clear to those skilled in the art that in an alternative arrangement the lid protrusion 5142 may be a recess, and the dock locking recess 5144 may be a corresponding protrusion. Alternatively one of any number of retaining means that are known in the art may be used to achieve the same means.

5.5.2.3 Heater Plate 5120

A heater plate 5120 is used to transfer heat to the water reservoir 5110. The heater plate 5120 may form a part of the reservoir dock 5130, and may be located on or near the base of the humidifier 5000 as shown in FIG. 14. The heater plate 5120 may be formed, for example, of a nickel chrome alloy or anodised aluminium.

5.6 Glossary

In certain forms of the present technology, one or more of the following definitions may apply. In other forms of the present technology, alternative definitions may apply.

5.6.1 General

Air: Air will be taken to include breathable gases, for example air with supplemental oxygen.

Continuous Positive Airway Pressure (CPAP): CPAP treatment will be taken to mean the application of a supply of air or breathable gas to the entrance to the airways at a pressure that is continuously positive with respect to atmosphere, and preferably approximately constant through a

respiratory cycle of a patient. In some forms, the pressure at the entrance to the airways will vary by a few centimeters of water within a single respiratory cycle, for example being higher during inhalation and lower during exhalation. In some forms, the pressure at the entrance to the airways will be slightly higher during exhalation, and slightly lower during inhalation. In some forms, the pressure will vary between different respiratory cycles of the patient, for example being increased in response to detection of indications of partial upper airway obstruction, and decreased in the absence of indications of partial upper airway obstruction.

5.6.2 Humidification System

Water reservoir: A water reservoir, or water tub, or humidifier reservoir, is a chamber that forms a part of the humidification system. It is configured to contain a body of liquid (e.g., water) aimed at imparting additional humidity to the flow of breathable air that passes through the water reservoir. It may comprise an air inlet and an air outlet, as well as a means (such as an opening or an openable lid) of filling the water reservoir with water.

5.6.3 Anatomy of the Respiratory System

Diaphragm: A sheet of muscle that extends across the bottom of the rib cage. The diaphragm separates the thoracic cavity, containing the heart, lungs and ribs, from the abdominal cavity. As the diaphragm contracts the volume of the thoracic cavity increases and air is drawn into the lungs.

Larynx: The larynx, or voice box houses the vocal folds and connects the inferior part of the pharynx (hypopharynx) with the trachea.

Lungs: The organs of respiration in humans. The conducting zone of the lungs contains the trachea, the bronchi, the bronchioles, and the terminal bronchioles. The respiratory zone contains the respiratory bronchioles, the alveolar ducts, and the alveoli.

Nasal cavity: The nasal cavity (or nasal fossa) is a large air filled space above and behind the nose in the middle of the face. The nasal cavity is divided in two by a vertical fin called the nasal septum. On the sides of the nasal cavity are three horizontal outgrowths called nasal conchae (singular "concha") or turbinates. To the front of the nasal cavity is the nose, while the back blends, via the choanae, into the nasopharynx.

Pharynx: The part of the throat situated immediately inferior to (below) the nasal cavity, and superior to the oesophagus and larynx. The pharynx is conventionally divided into three sections: the nasopharynx (epipharynx) (the nasal part of the pharynx), the oropharynx (mesopharynx) (the oral part of the pharynx), and the laryngopharynx (hypopharynx).

5.6.4 Materials

Silicone or Silicone Elastomer: A synthetic rubber. In this specification, a reference to silicone is a reference to liquid silicone rubber (LSR) or a compression moulded silicone rubber (CMSR). One form of commercially available LSR is SILASTIC (included in the range of products sold under this trademark), manufactured by Dow Corning. Another manufacturer of LSR is Wacker. Unless otherwise specified to the contrary, a preferred form of LSR has a Shore A (or Type A) indentation hardness in the range of about 35 to about 45 as measured using ASTM D2240.

Polycarbonate: a typically transparent thermoplastic polymer of Bisphenol-A Carbonate.

5.7 Other Remarks

*A portion of the disclosure of this patent document contains material which is subject to copyright protection.

The copyright owner has no objection to the facsimile reproduction by anyone of the patent document or the patent disclosure, as it appears in the Patent and Trademark Office patent file or records, but otherwise reserves all copyright rights whatsoever.

Unless the context clearly dictates otherwise and where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit, between the upper and lower limit of that range, and any other stated or intervening value in that stated range is encompassed within the technology. The upper and lower limits of these intervening ranges, which may be independently included in the intervening ranges, are also encompassed within the technology, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the technology.

Furthermore, where a value or values are stated herein as being implemented as part of the technology, it is understood that such values may be approximated, unless otherwise stated, and such values may be utilized to any suitable significant digit to the extent that a practical technical implementation may permit or require it.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this technology belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present technology, a limited number of the exemplary methods and materials are described herein.

When a particular material is identified as being preferably used to construct a component, obvious alternative materials with similar properties may be used as a substitute.

It must be noted that as used herein and in the appended claims, the singular forms "a", "an", and "the" include their plural equivalents, unless the context clearly dictates otherwise.

All publications mentioned herein are incorporated by reference to disclose and describe the methods and/or materials which are the subject of those publications. The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present technology is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided may be different from the actual publication dates, which may need to be independently confirmed.

Moreover, in interpreting the disclosure, all terms should be interpreted in the broadest reasonable manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

The subject headings used in the detailed description are included only for the ease of reference of the reader and should not be used to limit the subject matter found throughout the disclosure or the claims. The subject headings should not be used in construing the scope of the claims or the claim limitations.

Although the technology herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the prin-

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ciples and applications of the technology. In some instances, the terminology and symbols may imply specific details that are not required to practice the technology. For example, although the terms “first” and “second” may be used, unless otherwise specified, they are not intended to indicate any order but may be utilised to distinguish between distinct elements. Furthermore, although process steps in the methodologies may be described or illustrated in an order, such an ordering is not required. Those skilled in the art will recognize that such ordering may be modified and/or aspects thereof may be conducted concurrently or even synchronously.

It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the technology.

6 REFERENCE SIGNS LIST

7 Citations

7.1 Patent Literature

7.2 Non-Patent Literature

The invention claimed is:

1. An apparatus for humidifying a flow of breathable gas, comprising:

a heater plate;

a chamber structured and arranged for fluid communication with the flow of breathable gas; and

a reservoir including a cavity structured to hold a volume of liquid,

the reservoir comprising a base including a conductor plate comprising a heat conducting material, a lid pivotally coupled to the base, and a compressible member between the base and lid, the lid including an inlet configured to deliver the flow of breathable gas into the cavity and an outlet configured to deliver a humidified supply of breathable gas from the cavity,

wherein the reservoir including its base, lid, and compressible member form a unit that is removably engageable with the heater plate to arrange the conductor plate for thermal engagement with the heater plate so as to allow thermal transfer of heat from the heater plate to the volume of liquid within the cavity of the reservoir, and

wherein the compressible member is structured and arranged to allow movement of the reservoir in response to a pressure of the flow of breathable gas in the chamber, and wherein varying the pressure of the flow of breathable gas in the chamber varies a level of thermal engagement between the conductor plate and the heater plate.

2. The apparatus as claimed in claim 1, wherein the thermal engagement is in a first direction that is substantially normal to a surface of the conductor plate.

3. The apparatus as claimed in claim 2, wherein the apparatus is configured to vary a magnitude of a force between the conductor plate and the heater plate in the first direction as the pressure is varied.

4. The apparatus as claimed in claim 1, wherein the chamber is part of the reservoir.

5. The apparatus as claimed in claim 1, wherein the compressible member comprises an elastomeric material structured and arranged to allow said movement of the reservoir in response to the pressure of the flow of breathable gas in the chamber.

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6. The apparatus as claimed in claim 1, further comprising a dock configured to receive the reservoir, and the dock comprises the heater plate.

7. The apparatus as claimed in claim 6, wherein the dock further comprises a reservoir receiving cavity having a top portion and a bottom portion, the bottom portion having the heater plate located thereon, the reservoir receiving cavity configured to retain at least a portion of the reservoir therein.

8. The apparatus as claimed in claim 7, wherein the compressible member comprises an elastomeric material structured and arranged to allow said movement of the reservoir in response to the pressure of the flow of breathable gas in the chamber, and the compressible member is compressed to enable insertion of the reservoir into the reservoir receiving cavity of the dock.

9. The apparatus as claimed in claim 7, wherein the top portion of the reservoir receiving cavity is moveable between an open and closed configuration to facilitate insertion of the reservoir into the reservoir receiving cavity.

10. The apparatus according to claim 6, wherein the reservoir further comprises at least one handle to facilitate coupling of the reservoir to the dock.

11. The apparatus according to claim 7, wherein the reservoir further includes a retaining clip adapted to engage with a recess on the dock to retain the reservoir in the reservoir receiving cavity of the dock.

12. The apparatus according to claim 6, wherein the reservoir is structured to prevent refilling of the reservoir when the reservoir is coupled to the dock.

13. The apparatus according to claim 12, wherein at least a portion of the reservoir is prevented from being opened when the reservoir is coupled to the dock.

14. The apparatus according to claim 12, wherein the reservoir includes a re-filling cap.

15. The apparatus as claimed in claim 1, wherein the compressible member is configured to adjust in size as the pressure is varied to vary the level of thermal engagement between the heater plate and the conductor plate.

16. The apparatus according to claim 1, wherein the base includes the cavity structured to hold the volume of liquid.

17. The apparatus according to claim 1, wherein the compressible member comprises an elastomeric material structured and arranged to allow said movement of the reservoir in response to the pressure of the flow of breathable gas in the chamber, and the compressible member forms a seal between the base and the lid.

18. The apparatus according to claim 1, wherein the reservoir further includes a latch to secure the base and the lid together.

19. The apparatus according to claim 1, wherein the level of thermal engagement comprises a magnitude of force between the conductor plate and the heater plate.

20. The apparatus according to claim 1, wherein the conductor plate of the reservoir is directly engaged with the heater plate.

21. The apparatus according to claim 1, wherein the pressure of the flow of breathable gas in the chamber is configured to force the conductor plate against the heater plate to improve the level of thermal engagement.

22. The apparatus according to claim 1, wherein the reservoir and a dock comprising the heater plate are arranged to allow freedom of movement in a direction of the thermal engagement.

23. The apparatus according to claim 1, wherein the compressible member comprises an elastomeric material

structured and arranged to allow said movement of the reservoir in response to the pressure of the flow of breathable gas in the chamber.

24. The apparatus according to claim 1, further comprising an overflow protection element configured to prevent filling the reservoir above a predetermined maximum volume of water. 5

25. The apparatus according to claim 24, wherein the overflow protection element comprises at least one orifice formed in a wall of the reservoir, the at least one orifice defining an egress path of water when the predetermined maximum volume of water is exceeded. 10

26. The apparatus according to claim 24, wherein the overflow protection element comprises a sloped profile in a side profile of a wall of the reservoir, the sloped profile defining an egress path of water when the predetermined maximum volume of water is exceeded. 15

27. The apparatus according to claim 1, wherein the inlet includes an inlet tube and the outlet includes an outlet tube, wherein the inlet tube includes an inlet interior end and an inlet exterior end and the outlet tube includes an outlet interior end and an outlet exterior end, and wherein the inlet interior end and the outlet interior end are located within the cavity. 20

28. The apparatus according to claim 1, further comprising a dock including a cavity configured to receive the reservoir, the dock including a top portion configured to cover at least a portion of the reservoir and a bottom portion including the heater plate, wherein the top and bottom portions are configured to constrain at least a portion of the reservoir therebetween. 25 30

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